The Impact of Patient-Centered Medical Homes on Quality of Care and Medication Adherence in Patients with Diabetes Mellitus

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ABSTRACT

BACKGROUND: Current evidence suggests that patient-centered medical homes (PCMHs) potentially increase overall quality of disease management, including preventive care. However, there are mixed findings regarding quality of diabetes care, and little evidence exists with respect to the effect of PCMHs on medication adherence in patients with diabetes.

OBJECTIVE: To investigate associations between PCMHs and process measures of diabetes care, as well as adherence to oral hypoglycemic agents (OHAs) in patients with diabetes in a nationally representative U.S. sample.

METHODS: Using the 2009-2013 longitudinal data files from the Medical Expenditure Panel Survey, adult diabetes patients were identified. Patients whose usual sources of care have all PCMH features at baseline (i.e., enhanced access after hours and online, shared decision making, and enhanced patient engagement) were categorized as the PCMH group, which was compared with patients without PCMH features. Process measures of diabetes care included ≥ 2 hemoglobin A1c tests and ≥ 1 cholesterol test, foot examination, dilated eye examination, and flu vaccination during 1 year of follow-up. Medication possession ratio (MPR) during follow-up was calculated for patients with OHAs without any insulin use, with $\text{MPR} \geq 80\%$ considered to be adherent to OHAs. Univariate and multivariate regression models considering sampling strata and weights were used to examine the association between the PCMH and study outcomes.

RESULTS: A total of 3,334 patients with diabetes was identified, representing 61 million U.S. lives. The mean (SE) age was 61.6 (0.3) years, and 52.4% of patients were female. The mean (SE) years of having diabetes was 12.0 (0.2) years. Approximately 11.4% of the patients were categorized as the PCMH group at baseline, and only 3.6% of those patients remained in the PCMH group for 2 years. Of the diabetic patients identified, only 26.9% met all of the diabetes care process measure criteria defined in this study. A higher proportion of patients met process measure criteria in the PCMH group compared with the non-PCMH group (33.8% vs. 26.0%, respectively, $P=0.015$). The weighted mean MPR (95% CI) of OHAs from the 2 groups were not statistically different (0.68, 95% CI=0.63-0.74 for the PCMH group; 0.77, 95% CI=0.72-0.82 for the non-PCMH group, $P=0.675$), resulting in 47.4% of adherent patients in the study population. Overall, the PCMH group was associated with improvement in the process measures of diabetes care (adjusted odds ratios [OR]=1.42, 95% CI=1.06-1.91). The effect was greater among the patients who stayed in the PCMH group for 2 years (OR=2.09, 95% CI=1.27-3.45); were aged <65 years (OR=2.19, 95% CI=1.47-3.28); or had less than 3 comorbid conditions (OR=2.38, 95% CI=1.46-3.88). However, the PCMH group was not associated with an increased adherence to OHAs ($P=0.495$) or an increase in MPR ($P=0.570$).

CONCLUSIONS: Patients with all PCMH features were associated with improvement in the process measures of diabetes care, but not in adherence to OHAs. Future studies should investigate the mechanism of PCMHs in overall quality of care, as well as medication adherence.

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What is already known about this subject

- Recent evaluation studies of patient-centered medical homes (PCMHs) suggest positive effects on preventive care services, but there are mixed findings regarding quality of care, with limited evidence of medication adherence.
- The PCMH model provides a potential mechanism for improving medication adherence through enhanced coordination, case management, medication reconciliation, as well as shared decision making, and enhanced access to care.

What this study adds

- The PCMH care model was associated with improvement in process measures of diabetes care mainly because of increased rate of dilated eye examinations. Enhanced shared decision making and patient engagement features of the PCMH model likely influenced these findings.
- The effect of PCMHs seems to be greater in the younger population, as well as in patients with less comorbid conditions.
- The PCMH study group was not associated with an increased adherence to oral hypoglycemic agents, which suggests diverse effects of the PCMH model on different outcomes.

Patient-centered medical homes (PCMHs), or medical homes, have been suggested as a novel way to improve quality of care, patient and caregiver experience, and affordability.¹ The term “medical home” first appeared in *Standards of Child Health Care*, which was published by the American Academy of Pediatrics in 1967 and emphasized the importance of centralized medical records for children with special health care needs.² The current concept of PCMHs has been greatly expanded and is based on previous efforts to redesign primary care to provide for better quality of care.³ The PCMH model puts more emphasis on primary care physicians, who are responsible for leading interdisciplinary teams and encouraging cooperation and collaboration between providers and patients.⁴ Along with other organizations, the National Committee for Quality Assurance (NCQA) defined the joint principles of the PCMH model, which include a personal physician, physician-directed medical practice, coordinated and/or integrated care, whole-person orientation, high quality and safe care, enhanced access, and appropriate reimbursement for PCMH services.⁴ The PCMH model has received growing

attention—nearly 38,000 clinicians and 7,500 sites or clinics were recognized by the NCQA, and another 1,286 sites were certified by The Joint Commission as of June 2014.⁵

The literature examining the effects of PCMH interventions on utilization, quality of care, and health care costs is growing. Systematic reviews and recent studies have reported positive effects of the PCMH model on preventive care services such as cancer screening and vaccinations.^{1,6} However, studies show mixed findings regarding quality of care.⁶⁻¹³ Friedberg et al. (2015) found higher rates of process measures of diabetes care in the PCMH group compared with the usual care group,¹² while Rosenthal et al. (2015) reported no differences in Healthcare Effectiveness Data and Information Set (HEDIS) quality measures of diabetes care between the PCMH care and usual care groups.¹⁰ Moreover, little evidence exists that shows reduction of emergency department visits and overall cost savings from PCMH interventions.^{1,6,10,12,14-16}

The PCMH model also provides a potential mechanism for improving medication adherence through enhanced coordination, case management, and medication reconciliation,¹⁷ as well as shared decision making and access to care. Several studies have investigated the association between the PCMH model and increased use of medication therapy. Domino et al. (2009) showed that PCMH care for asthma improved the use of maintenance and rescue medications.¹⁸ Beadles et al. (2014) found a positive association between PCMHs and initiation of oral anticoagulation therapy.¹⁹ Beadles et al. (2015) reported a small absolute increase in proportion of days covered (PDC; a 4.8 percentage point increase)¹⁷ for PCMH enrollees, compared with non-PCMH enrollees, with multiple chronic conditions. More evidence is needed to further understand the effect of the PCMH care model on medication adherence.

This study investigated the effect of the PCMH model on patients with diabetes using longitudinal Medical Expenditure Panel Survey (MEPS) data files. The PCMH model is particularly applicable to diabetes care, since most patients with diabetes are managed by primary care providers, and many PCMH pilot programs focus on diabetes, such as the Chronic Care Initiative.^{12,20} MEPS collects data from a national U.S. representative sample, and the data source has the benefit of understanding patient perception of PCMHs.²¹

The purpose of this study was to assess the association between PCMHs and process measures of diabetes care, as well as adherence to oral hypoglycemic agents (OHAs) in patients with diabetes. The study hypothesized that patients whose usual sources of care have all PCMH features would have greater diabetes screening and/or exam rates and prescription medication use; therefore, the PCMH care model would improve the performance of diabetes process measures and increase medication adherence.

Methods

Data Source and Study Sample

MEPS is a nationally representative survey of the civilian non-institutionalized population of all ages in the United States. Conducted by the Agency for Healthcare Research and Quality, MEPS collects comprehensive data on health care utilization and expenditures. Data are collected from over 5 rounds of in-person interviews that cover a consecutive 2-year period. Patients with diabetes mellitus were identified using Clinical Classification Codes 049 and 050 (diabetes mellitus with or without complications) in medical condition files from the years 2009-2012. Among these patients, only respondents in the MEPS longitudinal files (MEPS panels 14, 15, 16, and 17) were included. Each longitudinal file has 2 years of data (year 1 and year 2). This study considered year 1 survey results as the baseline period and year 2 survey results as the follow-up period. PCMH features were determined at baseline (year 1), and study outcomes were assessed during follow-up (year 2). Age exclusion criteria (aged < 18 years at baseline) were further applied so only adult diabetic patients were included in the study. The final study sample included individuals who had usual care providers for both years and who responded “yes” for diabetes diagnosis by health professionals at baseline. For the medication adherence outcome, the analysis was restricted to individuals with at least 1 OHA (therapeutic subclass=99)²² at baseline without any insulin use during follow-up (therapeutic subclass=215 or “no” for the question of whether they were treated with insulin injections). Patients who were on insulin therapy at baseline but no longer received insulin during follow-up (2.7% of the population) were included, since adherence to OHA calculation was not affected by baseline insulin use.

Definition of PCMH

The PCMH care model was defined using the provider-related questionnaires in MEPS. These questionnaires included questions regarding enhanced access to the usual care provider after hours and online, shared decision making, and enhanced patient engagement. The following selected questions were adopted from previous literature that investigated the effectiveness of PCMH in MEPS^{21,23-25}:

1. “How difficult is it to contact [medical provider] after regular hours in case of urgent medical needs?”
2. “Does [medical provider] have office hours at night or on weekends?”
3. “How difficult is it to contact [medical provider] during regular business hours over the telephone about a health problem?”

4. “How often would [medical provider] ask patient to help make the decision?”
5. “Does [medical provider] usually ask about prescription medications and treatments other doctors may give them?”

The responses were categorized as (a) a positive response (“usually/always” for frequency questions and “not too difficult/not at all difficult” for difficulty questions); (b) missing (“don’t know/refused”); and (c) a negative response for others. Patients with positive responses to all 5 questions were categorized as the PCMH group; all others were considered the non-PCMH group.

Outcomes

Process Measures of Diabetes Care. The American Diabetes Association (ADA) recommends the following for diabetes care: (a) 2 or more hemoglobin A1c laboratory tests, (b) cholesterol tests, (c) a foot examination, (d) a dilated eye examination, and (e) flu vaccination every year.²⁶ Consistent with ADA recommendations, responses to these 5 process measures of diabetes care were used to define optimal diabetes care. Patients who were adherent to all 5 ADA recommendations were considered optimal. The selected questions from the diabetes care survey in the MEPS household component are as follows:

1. “During [year], how many times did a doctor, nurse, or other health professional check your blood for glycosylated hemoglobin or ‘hemoglobin A1c’?”
2. “Which of the following year(s) did you have your blood cholesterol checked?”
3. “Which of the following year(s) did a doctor or other health professional check your feet for any sores or irritations?”
4. “Which of the following year(s) did you have an eye exam in which your pupils were dilated?”
5. “Which of the following year(s) did you get a flu vaccination?”

Medication Adherence. Medication possession ratio (MPR) during 1 year of follow-up was calculated for patients with at least 1 OHA at baseline without any insulin use. The MPR was calculated using prescription pharmacy records in MEPS. Baseline OHAs were categorized using therapeutic subclasses that included biguanides, sulfonylureas, alpha glucosidase inhibitors, thiazolidinediones, meglitinides, combination agents, and dipeptidyl peptidase-4 inhibitors. Assuming that patients were expected to continue all baseline subclasses of OHAs during follow-up, the average MPR for each OHA class was calculated. The MPR was calculated by summing the days supply for each OHA class and dividing by 365 days. Then, the average MPR was calculated using MPRs for each OHA class. The calculated MPR was truncated at 100%, and $MPR \geq 80\%$ was considered adherent to any OHA.²⁷ For example, if a patient had metformin (biguanides) and glimepiride (sulfonylurea) prescriptions at baseline, the MPR of metformin and the MPR of glimepiride were calculated separately and then the average of both MPRs was calculated. This method allowed

for switch therapy between drugs within the same class. If the patient switched from glimepiride to glipizide (sulfonylurea), the days supply of both drugs (glimepiride or glipizide) were included in calculating the MPR of sulfonylurea. For patients who switched to different classes of OHAs during follow-up without any baseline OHA use, only MPRs of the new drug classes were calculated. For example, if a patient had metformin (biguanides) prescriptions, but only had rosiglitazone (thiazolidinedione) prescriptions during follow-up, the MPR of rosiglitazone was calculated, assuming that this patient had switched from metformin to rosiglitazone. For patients who added another class of OHA, only the average MPR of baseline OHAs was calculated, since this augmentation might happen in the middle of follow-up.

Approximately 31.5% of the pharmacy records had missing days supply or incorrect data (days supply of zero). Four methods were used to impute missing values: (1) the same days supply when the same drug name and the same quantity for the same individual was available (5.0% of the total missing values); (2) the calculated days supply when the same drug name for the same individual was available, applying the same dose per day (5.2% of the missing values); (3) the calculated days supply applying the most frequent dose per day per OHA from the data (83.6% of the missing values); and (4) the most frequent days supply, applying the most frequent number of pills per day per OHA and quantity from the data (6.3% of missing values). This missing imputation strategy was tested in the sensitivity analyses.

Covariates

Covariates included in the model were selected a priori based on adherence literature and availability of data. Patient sociodemographic variables were included, such as age, race/ethnicity, sex, marital status, education, and region. Perceived health of patients, as well as years of diabetes and insulin dependence (only for the diabetes process measure analysis) were considered as covariates. Disease severity was controlled using a Elixhauser comorbidity score or number of comorbid conditions to consider multiple chronic conditions.²⁸⁻³⁰ For the adherence outcome, a few additional covariates were considered, such as number of OHA classes (proxy for polypharmacy), use of ≥ 1 brand-name OHA (defined by using National Drug Code numbers), copayment for OHAs, and depression at baseline. The list of covariates was finalized after a multicollinearity check using the variance inflation factor.

Statistical Analyses

Descriptive statistics (t-tests for continuous variables and Rao-Scott chi-square tests for categorical variables) were conducted to compare the PCMH and non-PCMH groups. Univariate and multivariate logistic regression models considering sampling strata and weights were used to examine the association

TABLE 1 Baseline Characteristics

	PCMH No		PCMH Yes		Total		P Value
	N	Weighted %	N	Weighted %	N	Weighted %	
Overall Cohort	(n = 2,956; weighted n = 54 million)		(n = 378; weighted n = 6.9 million)		(N = 3,334; weighted N = 61 million)		
Panel							
14	718	23.3	71	19.8	789	22.9	0.5577
15	649	27.2	88	30.3	737	27.6	
16	826	24.6	114	25.3	940	24.7	
17	763	24.9	105	24.6	868	24.9	
Mean age (SE)		61.7 (0.3)		61.5 (0.9)		61.6 (0.3)	0.8894
18-45 years	356	11.0	43	11.6	399	11.0	0.9208
45-64 years	1,368	45.0	174	45.6	1,542	45.1	
≥65 years	1,232	44.0	161	42.8	1,393	43.9	
Sex							
Male	1,305	47.9	169	45.1	1,474	47.6	0.3457
Female	1,651	52.1	209	54.9	1,860	52.4	
Race/ethnicity							
White	1,264	64.0	155	65.4	1,419	64.2	0.9493
Black	765	15.4	88	14.7	853	15.3	
Nonwhite Hispanic	672	13.5	95	13.6	767	13.6	
Asian/others	255	7.0	40	6.3	295	7.0	
Spouse/marital status							
Spouse in the house	1,534	56.6	200	56.8	1,734	56.7	0.9642
Not married/no spouse	1,422	43.4	178	43.2	1,600	43.3	
Education							
Lower than high school	1,719	55.6	205	54.5	1,924	55.5	0.8667
High school	465	19.2	67	20.8	532	19.4	
College or more	772	25.2	106	24.7	878	25.1	
Region							
Northeast	456	17.1	78	21.2	534	17.5	0.0346
Midwest	575	22.3	77	27.5	652	22.9	
South	1,274	41.6	113	30.2	1,387	40.3	
West	651	19.0	110	21.1	761	19.3	
Perceived health status							
Excellent/good	238	9.3	30	9.5	268	9.3	0.9100
Good	947	35.4	127	36.7	1,074	35.5	
Fair/poor	1,771	55.3	221	53.7	1,992	55.1	
Years of diabetes		11.9 (0.3)		12.8 (0.9)		12.0 (0.3)	0.3785
Insulin use							
Yes	902	29.9	140	36.4	1,042	30.7	0.0745
No	2,036	69.6	234	62.7	2,270	68.8	
Not available	18	0.5	4	0.9	22	0.5	
Number of chronic conditions, mean (SE)		3.6 (0.04)		3.5 (0.1)		3.5 (0.03)	0.5667
1	249	7.9	49	12.5	298	8.4	0.9343
2	528	17.2	68	16.5	596	17.1	
3	845	27.0	100	22.2	945	26.4	
4	640	22.8	80	24.5	720	23.0	
5 or more	694	25.1	81	24.3	775	25.0	
Mean Elixhauser comorbidity score (SE)		3.2 (0.14)		3.2 (0.39)		3.2 (0.13)	0.9061
Comorbidity							
Hypertension	2,254	74.3	281	74.0	2,535	74.3	0.9343
Dyslipidemia	1,981	67.7	238	65.0	2,219	67.4	0.4203
Coronary artery disease	590	20.7	73	22.0	663	20.9	0.6274
Arthritis	581	20.3	69	21.1	650	20.4	0.7944
Depression	446	16.6	51	15.2	497	16.4	0.5745
Cancer	301	12.1	50	15.1	351	12.4	0.1645

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TABLE 1 Baseline Characteristics (continued)

	PCMH No		PCMH Yes		Total		P Value
	N	Weighted %	N	Weighted %	N	Weighted %	
Overall Cohort	(n = 2,956; weighted n = 54 million)		(n = 378; weighted n = 6.9 million)		(N = 3,334; weighted N = 61 million)		
Comorbidity							
Asthma	308	10.5	40	11.6	348	10.6	0.6097
Chronic obstructive pulmonary disease	277	11.0	27	7.8	304	10.6	0.1235
Stroke	186	6.5	19	5.1	205	6.4	0.3707
Congestive heart failure	83	2.8	10	3.0	93	2.8	0.8392
Dementia	59	2.1	9	2.1	68	2.1	0.9599
Osteoporosis	64	2.2	7	1.5	71	2.1	0.4463
Schizophrenia	29	0.9	2	0.8	31	0.9	0.8764
Chronic kidney disease	15	0.4	4	1.1	19	0.5	0.0018
Adherence Cohort	(n = 1,426; weighted n = 26 million)		(n = 156; weighted; n = 2.8 million)		(N = 1,582; weighted N = 2.9 million)		
Baseline number of OHA classes							
1	859	59.5	98	62.9	957	59.8	0.8818
2	458	32.5	48	30.2	506	32.3	
3	103	7.6	9	6.4	112	7.5	
≥4	6	0.4	1	0.5	7	0.4	
Baseline ≥1 brand-name OHAs							
Yes	363	26.4	46	33.5	409	27.1	
No	1,063	73.6	110	66.5	1,173	72.9	0.1012
Mean baseline copay for OHA (SE)		\$100.4 (7.1)		\$89.6 (15.0)		\$99.3 (6.4)	0.5318
Mean baseline total OHA expenditure (SE)		\$464.2 (30.0)		\$451.9 (87.0)		\$471.9 (37.0)	0.4233

OHA = oral hypoglycemic agents; PCMH = patient-centered medical home; SE = standard error.

OHA = oral hypoglycemic agents; PCMH = patient-centered medical home; SE = standard error.

between PCMHs and diabetes process measures, as well as medication adherence. Potential confounding factors previously listed were tested and added to the multivariate logistic regression model as covariates.

A priori subgroup analyses were conducted to test whether the effect of PCMHs is consistent across the different subgroups of the population. Age group (aged over 65 years, less than 65 years) and number of comorbid conditions (3 or more, less than 3) were considered in this analysis. Sensitivity analyses were conducted using different MPR cutoffs for the definition of medication adherence, MPR of any OHA, excluding missing values in days supply, and MPR as a continuous variable. A *P* value of <0.05 was considered statistically significant. All statistical analyses were performed using SAS, version 9.4 (SAS Institute, Cary, NC).

Results

A total of 3,334 patients with diabetes was identified, representing 61 million U.S. lives, by applying survey weights. The mean (standard error [SE]) age was 61.6 (0.3) years, and 52.4% of the patients were female. The mean (SE) duration of diabetes was 12.0 (0.3) years; 30.7% of the patients were on insulin at baseline, and the mean (SE) number of comorbid conditions was 3.5 (0.03) (Table 1). A higher proportion of

patients in the PCMH group were in the Northeast/Midwest regions. Approximately, 11.4% of the patients were categorized as a PCMH group at baseline, and 88.6% were considered as the non-PCMH group. For the adherence outcome evaluation, 1,582 patients were identified after applying additional exclusion criteria, and 9.8% of that number were considered as PCMH patients, with 90.2% considered as non-PCMH patients.

The majority of patients (about 80%) responded that their usual care providers ask patients to help decide between treatments, ask about treatment prescribed by other doctors, and they have no or less difficulty in contacting their providers by phone. However, a relatively smaller percentage of patients (28.2%-43.8%) responded that they have no difficulty in contacting their providers after hours, at night, or on weekends. Only 3.6% of the patients remained in the PCMH group over the 2 years. During the follow-up year, a large proportion of patients changed their responses to “no” or “unknown” because they experienced difficulty contacting physicians after hours or on nights/weekends during follow-up (Table 2).

Table 3 summarizes the process measures of diabetes care and adherence to OHAs by the PCMH group. Although 50%-80% of each process measure criteria were met, only 26.9% of the diabetic patients met all diabetes process measure performance criteria defined in this study. A1c testing had the lowest

TABLE 2 Summary of Patient-Centered Medical Home Status

	Positive		Negative		Unknown	
	N	Weighted %	N	Weighted %	N	Weighted %
Response at Baseline (Year 1)						
Difficulty contacting after hours	1,458	43.8	927	25.2	949	31.0
Difficulty contacting nights/weekends	930	28.2	2,111	63.3	293	8.5
Difficulty contacting over the phone	2,690	81.2	547	16.2	97	2.6
Ask patient to help decide between treatments	2,603	78.9	521	14.6	210	6.5
Ask about treatments prescribed by other doctors	2,691	80.0	563	17.6	80	2.4
Positive Response at Baseline (Year 1)						
Difficulty contacting after hours	866	59.9	307	19.3	285	20.8
Difficulty contacting nights/weekends	557	62.3	311	31.4	62	6.2
Difficulty contacting over the phone	2,308	86.0	319	11.5	63	2.5
Ask patient to help decide between treatments	2,167	84.5	348	12.1	88	3.4
Ask about treatments prescribed by other doctors	2,263	85.1	381	13.2	47	1.7

percentage (50.5%), and cholesterol testing had the highest percentage (86.3%). A higher proportion of patients met process measure criteria in the PCMH group compared with the non-PCMH group (33.8% vs. 26.0%, respectively, $P=0.015$). Higher rates of dilated eye examinations were observed in the PCMH group, compared with the non-PCMH group (73.3% vs. 64.7%, respectively, $P=0.015$); however, other exam or testing rates were not statistically significantly different in both groups.

The weighted mean MPR (95% confidence interval [CI]) for the OHAs were not statistically different in both groups. The mean MPR (95% CI) of baseline OHAs was 0.68 (0.63-0.74) for the PCMH group and 0.77 (0.72-0.82) for the non-PCMH group ($P=0.675$). The proportion of patients adherent to OHAs was relatively low and not statistically different between the PCMH and non-PCMH groups (44.9% vs. 47.6%, respectively, $P=0.565$). The proportion was slightly higher when calculating adherence to any OHA (60.9% vs. 63.4%, respectively, $P=0.557$).

Univariate and multivariate analyses showed that the PCMH group was associated with improvement in overall process measures of diabetes care (adjusted odds ratio [OR] = 1.42, 95% CI = 1.06-1.91; Figure 1 and Appendix A, available in online article). The PCMH group was associated with improvement in dilated eye exams (OR = 1.49, 95% CI = 1.08-2.05). All the other process measures were not statistically significant. White race, higher level of education, perceived good health condition, longer duration of diabetes, and higher Elixhauser comorbidity score were also associated with better performance of the diabetes process measures (Appendix A). The effect was greater in patients who stayed in the PCMH group for 2 years (OR = 2.09, 95% CI = 1.29-3.45; Figure 1). Investigation of each specific PCMH principle showed that asking patients to help decide between treatments (OR = 1.34, 95% CI = 1.11-1.60) and asking patients about their treatments from other providers (OR = 1.45, 95% CI = 1.14-1.85) were highly associated with diabetes process measures. Subgroup analysis further reported that the

effect of PCMH principles was greater in patients with less comorbid conditions (less than 3; OR = 2.38, 95% CI = 1.46-3.88) and in the younger patient population (aged < 65 years; OR = 2.19, 95% CI = 1.47-3.28).

However, the PCMH group was not associated with an increased adherence to OHAs (OR = 0.87, 95% CI = 0.58-1.30; Figure 2 and Appendix B, available in online article) or an increase in MPR ($P=0.570$). Older age and higher OHA copayment were associated with medication adherence (Appendix B). Subgroup analyses and sensitivity analyses consistently showed no statistically significant association between PCMH care and medication adherence.

Discussion

This study suggests that PCMHs may improve the performance of diabetes process measures. The PCMH group was associated with a 42% higher likelihood of compliance with the ADA-recommended diabetes process measures. These findings are mostly driven by the improvement of dilated eye exam rates rather than A1c or cholesterol tests. Foot exams and flu vaccinations showed positive increases; however, these findings were not statistically significant. In addition, the study findings also indicated a potential long-term effect of PCMH principles on the process measure outcome. Patients in the PCMH group for 2 consecutive years showed a higher likelihood of better performance on the diabetes care process measures. Although there are mixed results in diabetes quality of care,^{9,10,15} the findings in this study strengthen some of the previous study conclusions. A meta-analysis of earlier PCMH evaluation studies showed small-to-moderate positive effects on the delivery of preventive care services.⁶ More recent PCMH pilot programs reported improvement in quality measures of diabetes, and the effect seemed to be greater in long-term follow-up.^{12,13} Differences between the PCMH pilot and comparison practices became larger after 3 years of follow-up in most of the quality

TABLE 3 Process Measures of Diabetes Care and Medication Adherence by the PCMH Group

	PCMH				Total		P Value
	No		Yes				
	N	Weighted %	N	Weighted %	N	Weighted %	
Overall Cohort	(n = 2,956)		(n = 378)		(N=3,334)		
Process measures of diabetes care	689	26.0	113	33.8	802	26.9	0.0145
A1c test	1,357	50.3	182	52.3	1,539	50.5	0.578
Cholesterol test	2,517	86.4	323	86.0	2,840	86.3	0.8817
Diabetes foot examination	2,132	73.2	285	76.9	2,417	73.6	0.2824
Dilated eye examination	1,864	64.7	263	73.3	2,127	65.7	0.0146
Flu vaccination	1,866	64.7	252	67.8	2,118	65.1	0.4293
Adherence Cohort	(n = 1,426)		(n = 156)		(N = 1,582)		
Adherence to OHAs							
Mean (95% CI) MPR of baseline OHAs	–	0.77 (0.72-0.82)	–	0.68 (0.63-0.74)	–	0.69 (0.68-0.71)	0.6754
Mean (95% CI) MPR of any OHA	–	0.78 (0.76-0.80)	–	0.69 (0.67-0.71)	–	0.78 (0.77-0.80)	0.5610
% of patients adherent to baseline OHAs	667	47.6	70	44.9		47.4	0.5648
% of patients adherent to any OHA	886	63.4	94	60.9		63.1	0.5571
Mean (95% CI) MPR of baseline OHAs by OHA copayment amount							
<\$13	621	0.64 (0.61-0.66)	60	0.68 (0.60-0.77)	681	0.64 (0.61-0.67)	
\$13-\$44	280	0.71 (0.66-0.75)	37	0.69 (0.56-0.82)	317	0.70 (0.66-0.75)	
\$45-\$112	265	0.76 (0.72-0.79)	36	0.64 (0.53-0.75)	301	0.74 (0.71-0.78)	
≥\$113	260	0.73 (0.70-0.77)	23	0.73 (0.59-0.87)	283	0.73 (0.70-0.77)	
Mean (95% CI) MPR of baseline OHAs by ≥1 brand-name OHA use							
Yes	363	0.70 (0.66-0.74)	46	0.70 (0.61-0.80)	409	0.69 (0.67-0.71)	
No	1,063	0.69 (0.67-0.71)	110	0.67 (0.61-0.74)	1,173	0.70 (0.67-0.73)	
Mean (95% CI) MPR of baseline OHAs by number of OHA classes at baseline							
1	859	0.68 (0.65-0.71)	98	0.65 (0.58-0.72)	957	0.68 (0.65-0.70)	
2	458	0.71 (0.68-0.74)	48	0.75 (0.66-0.83)	506	0.72 (0.69-0.74)	
≥3	109	0.72 (0.67-0.77)	10	0.73 (0.56-0.90)	119	0.72 (0.67-0.77)	

CI=confidence interval; MPR=medication possession ratio; OHA=oral hypoglycemic agent; PCMH=patient-centered medical home.

measures.^{12,13} These findings are consistent across diabetes process measures such as A1c testing, cholesterol testing, nephropathy monitoring, and eye examinations.

This study did not find that the PCMH model improved adherence to OHAs. This finding was consistent across subgroup analyses and sensitivity analyses. One reason for this lack of effectiveness may be because this study evaluated medication adherence among the prevalent diabetes population. The mean duration of diabetes in this population was 12 years, and this study identified patients who already had initiated OHAs at baseline. The medication-taking behavior of these patients may have already formed; therefore, the PCMH model might be less likely to influence medication adherence. The current evidence for the effect of the PCMH model on medication adherence among prevalent patients is limited. The 2015 Beadles et al. study found a small increase in PDC of newly initiating diabetes medications in patients with multiple chronic conditions,¹⁷ and the 2014 Beadles et al. study also found an association between the PCMH model and a higher rate of initiating oral anticoagulation therapy in new patients with atrial fibrillation.¹⁹

These mixed study findings suggest the necessity of understanding the effect of the PCMH model on various outcome measures. The PCMH care model focuses on coordinated and/or integrated care, whole-person orientation, and enhanced access to care. These features may be effective in preventive care or in process measures that require coordination with other health care professionals. Dilated eye examinations by ophthalmologists or optometrists is a good example of coordinated care; enhanced access and shared decision making might increase dilated eye exam rates. On the other hand, patients with diabetes who already have initiated their medications may not be influenced as much because they had better access to primary care and/or better chances of shared decision making. Instead, the PCMH principles may be more important in newly initiating therapy or transitioning of care. Other features of the PCMH model, such as adoption of electronic health records or use of case managers, might have more of an effect on improving medication adherence. Futures studies will be helpful to further understand the effect of the PCMH care model on different outcomes so that, ultimately, useful interventions can be designed for each outcome.

FIGURE 1 Adjusted Odds Ratios (95% CI) for Each PCMH Feature and Subgroup Analyses on Process Measures of Diabetes Care

Note: For odds ratios, age, sex, race/ethnicity, education, perceived health, years of diabetes, number of comorbidity, depression variables were adjusted. CI=confidence interval; PCMH=patient-centered medical home.

Subgroup analyses suggest that the PCMH model is more effective with patients who have less comorbidities, as well as with younger patients. These findings may be because patients with a single disease or less comorbid conditions usually have less interactions with health care providers so have less opportunity to receive preventive care compared with patients who have multiple chronic conditions. Also, younger patients or patients with less comorbidities tend to be less serious about their condition, which may lead to a greater effect of the PCMH model on the diabetes process measures.³¹ Subgroup analyses of medication adherence suggest different results, although the findings are not statistically significant. The number of comorbid conditions seems to affect medication adherence, with a higher number of comorbid conditions having more of an effect than a lower number of conditions. These findings also suggest that the PCMH model affects various outcomes differently. The process measures of diabetes care are probably more related to interaction with the health care system, while medication adherence is more associated with a person's self-control. Although patients interact more with clinicians, patients with multiple comorbidities may have a hard time managing and adhering to multiple medications. The effect of the PCMH model on medication adherence and other measures needs to be further explored.

From the multivariate analysis, we confirmed several widely known factors associated with adherence. Racial disparities were found in this study. Black and Hispanic patients were less likely to adhere to the ADA-recommended diabetes care process measures. Higher education was associated with better performance of process measures. Patients who stated that they were in good health were associated with better performance, which may be interpreted as health consciousness. Longer duration of diabetes and higher Elixhauser comorbidity scores can be interpreted as severity of diseases, and patients with severe disease conditions were more likely to meet the process measure criteria. Many of these covariates were not statistically significant in the medication adherence analysis. Higher copayment amount was associated with better adherence. These findings may be counterintuitive; however, this variable showed how much money that an individual actually paid in the baseline year rather than the amount that the individual had to pay in the follow-up year. Therefore, this variable may be related to how well a patient filled his or her prescriptions at baseline. This study provides particular patient perspectives of the PCMH model. Current PCMH evaluation studies are mostly from pilot projects or from PCMHs certified by the NCQA. Although patient-reported PCMH principles may not

FIGURE 2 Adjusted Odds Ratios (95% CI) from Subgroup and Sensitivity Analyses on Medication Adherence

Note: For odds ratios, age, sex, race/ethnicity, education, perceived health, years of diabetes, number of comorbidity, depression variables were adjusted. CI=confidence interval; MPR=medication possession ratio; OHA=oral hypoglycemic agent; PCMH=patient-centered medical home.

necessarily be consistent with PCMH certification, patients may receive a higher quality of care that is consistent with PCMH principles before formal recognition.³² In addition, self-reported outcomes provide unique patient perspectives on the PCMH model.⁵ The data for each PCMH feature provide the opportunity to further understand the effect of the PCMH model. Several studies that investigated PCMHs using survey data indicated that survey data based on patient reporting can reliably predict outcomes similar to existing evidence.^{5,21,23-25}

This study showed that positive responses in shared decision making and enhanced patient engagement questions seem to be highly associated with the process measures of diabetes care. Asking patients to help decide treatment and asking about treatments by other doctors indicated a higher likelihood of improvement in the process measure; however, difficulty in contacting usual care providers was not associated with the process measure outcome. These findings are related to previous findings using the same data source. Stockbridge et al. (2014) reported higher pharmacy expenditures for individuals whose providers asked about medications and treatments prescribed by other doctors.²¹ However, this study also found lower total expenditures for the individuals who had no difficulty in contacting the regular source of care over the telephone during regular business hours. Again, this shows that each PCMH feature may influence various outcomes differently.

Limitations

This study has several limitations. The definition of PCMHs was based on patient responses. Although this study provides unique patient perspectives on PCMHs, self-reported patient perceptions may not accurately define the PCMH model. Some PCMH principles have not been captured in MEPS (e.g., adoption of electronic medical records, use of evidence-based clinical protocols, and degree of care coordination when transitioning between different levels of care) or may not be familiar to patients, which may lead to bias in the measurement. The number of questionnaires used to define PCMHs in this study are relatively smaller than the questionnaires used to define PCMHs among the pediatric population using the MEPS data.²³⁻²⁵

As with other observational studies, this study's findings may be biased because of potential confounding factors. In this study, multivariate analysis was used to control for observed confounding factors; however, unmeasured confounders such as successful provider-patient relationships that are not necessarily characteristics of PCMHs might lead to the study findings. This study suffers from typical nonrespondent bias or recall bias that are present in survey studies. As in other survey studies, this analysis had to rely on available data.

The medication adherence outcome was measured using MPR from the MEPS pharmacy files. Although the MEPS

prescription drug data are reportedly accurate,³³ missing values in days supply records and unavailable fill dates are limitations of studying medication adherence using MEPS. To overcome this, MPRs were calculated in different ways, and sensitivity analyses were conducted around the definition of medication adherence. The study population was restricted to patients who initiated OHAs, and insulin users were excluded, since accurate calculation of refill adherence is challenging for insulin users.

Despite these limitations, this study has several strengths. It is one of the few studies examining the PCMH effect on medication adherence in a nationally representative U.S. sample. This study used panel data to investigate the association between PCMHs and process measures of diabetes care, along with medication adherence, to avoid the typical limitations of a cross-sectional survey study. Unique patient perspectives on PCMHs for various outcomes further provided insights regarding implementation of PCMHs for the broader population.

Conclusions

The PCMH model was associated with improvement in the process measures of diabetes care, potentially driven by enhanced shared decision making and patient engagement. However, the PCMH model was not associated with increased adherence to OHAs. Future studies should further explore the effect of PCMHs on various outcomes to understand these mixed findings and to suggest changes in the health care system to improve patient adherence.

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REFERENCES

- Peikes D, Zutshi A, Genevro JL, Parchman ML, Meyers DS. Early evaluations of the medical home: building on a promising start. *Am J Manag Care*. 2012;18(2):105-16.
- Sia C, Tonniges TF, Osterhus E, Taba S. History of the medical home concept. *Pediatrics*. 2004;113(5 Suppl):1473-78.
- Kilo CM, Wasson JH. Practice redesign and the patient-centered medical home: history, promises, and challenges. *Health Aff (Millwood)*. 2010;29(5):773-78.
- American Academy of Family Physicians, American Academy of Pediatrics, American College of Physicians, American Osteopathic Association. Joint principles of a patient-centered medical home. March 2007. Available at: http://www.aafp.org/dam/AAFP/documents/practice_management/pcmh/initiatives/PCMHJoint.pdf. Accessed October 1, 2016.
- Pourat N, Charles SA, Snyder S. Availability of care concordant with patient-centered medical home principles among those with chronic conditions: measuring care outcomes. *Med Care*. 2016;54(3):262-68.
- Jackson GL, Powers BJ, Chatterjee R, et al. Improving patient care. The patient centered medical home. A systematic review. *Ann Intern Med*. 2013;158(3):169-78.
- Hoff T, Weller W, DePuccio M. The patient-centered medical home: a review of recent research. *Med Care Res Rev*. 2012;69(6):619-44.
- Kern LM, Edwards A, Kaushal R. The patient-centered medical home, electronic health records, and quality of care. *Ann Intern Med*. 2014;160(11):741-49.
- Rosenthal MB, Alidina S, Friedberg MW, et al. Impact of the Cincinnati Aligning Forces for Quality multi-payer patient centered medical home pilot on health care quality, utilization, and costs. *Med Care Res Rev*. 2016;73(5):532-45.
- Rosenthal MB, Sinaiko AD, Eastman D, Chapman B, Partridge G. Impact of the Rochester Medical Home Initiative on primary care practices, quality, utilization, and costs. *Med Care*. 2015;53(11):967-73.
- Rosenthal MB, Alidina S, Friedberg MW, et al. A difference-in-difference analysis of changes in quality, utilization and cost following the Colorado Multi-Payer Patient-Centered Medical Home Pilot. *J Gen Intern Med*. 2016;31(3):289-96.
- Friedberg MW, Rosenthal MB, Werner RM, Volpp KG, Schneider EC. Effects of a medical home and shared savings intervention on quality and utilization of care. *JAMA Intern Med*. 2015;175(8):1362-68.
- Friedberg MW, Schneider EC, Rosenthal MB, Volpp KG, Werner RM. Association between participation in a multipayer medical home intervention and changes in quality, utilization, and costs of care. *JAMA*. 2014;311(8):815-25.
- David G, Gunnarsson C, Saynisch PA, Chawla R, Nigam S. Do patient-centered medical homes reduce emergency department visits? *Health Serv Res*. 2015;50(2):418-39.
- Dale SB, Ghosh A, Peikes DN, et al. Two-year costs and quality in the Comprehensive Primary Care Initiative. *N Engl J Med*. 2016;374(24):2345-56.
- Cole ES, Campbell C, Diana ML, Webber L, Culbertson R. Patient-centered medical homes in Louisiana had minimal impact on Medicaid population's use of acute care and costs. *Health Aff (Millwood)*. 2015;34(1):87-94.
- Beadles CA, Farley JF, Ellis AR, et al. Do medical homes increase medication adherence for persons with multiple chronic conditions? *Med Care*. 2015;53(2):168-76.
- Domino ME, Humble C, Lawrence WW Jr, Wegner S. Enhancing the medical homes model for children with asthma. *Med Care*. 2009;47(11):1113-20.
- Beadles CA, Hassmiller Lich K, Viera AJ, Greene SB, Brookhart MA, Weinberger M. Patient-centered medical homes and oral anticoagulation therapy initiation. *Med Care Res Rev*. 2014;71(2):174-91.
- McGinley EL, Gabbay RA. The impact of new payment models on quality of diabetes care and outcomes. *Curr Diab Rep*. 2016;16(6):51.
- Stockbridge EL, Philpot LM, Pagán JA. Patient-centered medical home features and expenditures by medicare beneficiaries. *Am J Manag Care*. 2014;20(5):379-85.

22. Stagnitti, MN. Trends in utilization and expenditures of prescribed drugs treating diabetes, hypertension, and high cholesterol for persons under age 40 in the U.S. civilian noninstitutionalized population, 2000 and 2010. Statistical Brief #407. June 2013. Agency for Healthcare Research and Quality, Rockville, MD. Available at: http://meps.ahrq.gov/mepsweb/data_files/publications/st407/stat407.shtml. Accessed October 1, 2016.
23. Romaine MA, Bell JF, Grossman DC. Medical home access and health care use and expenditures among children with special health care needs. *Arch Pediatr Adolesc Med*. 2012;166(4):323-30.
24. Romaine MA, Bell JF, Grossman DC. Health care use and expenditures associated with access to the medical home for children and youth. *Med Care*. 2012;50(3):262-69.
25. Han B, Yu H, Friedberg MW. Evaluating the impact of parent-reported medical home status on children's health care utilization, expenditures, and quality: a difference-in-differences analysis with causal inference methods. *Health Serv Res*. June 3, 2016. Epub ahead of print.
26. American Diabetes Association. Strategies for improving care. Sec. 1. In: Standards of medical care in diabetes 2016. *Diabetes Care*. 2016;39 (Suppl 1):S6-S12.
27. Peterson AM, Nau DP, Cramer JA, Benner J, Gwady-Sridhar F, Nichol M. A checklist for medication compliance and persistence studies using retrospective databases. *Value Health*. 2007;10(1):3-12.
28. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. *Med Care*. 1998;36(1):8-27.
29. Thompson NR, Fan Y, Dalton JE, et al. A new Elixhauser-based comorbidity summary measure to predict in-hospital mortality. *Med Care*. 2015;53(4):374-79.
30. Goodman RA, Posner SF, Huang ES, Parekh AK, Koh HK. Defining and measuring chronic conditions: imperatives for research, policy, program, and practice. *Prev Chronic Dis*. 2013;10:E66. Published online April 25, 2013. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3652713/>. Accessed October 1, 2016.
31. Juth V, Silver RC, Sender L. The shared experience of adolescent and young adult cancer patients and their caregivers. *Psychooncology*. 2015;24(12):1746-53.
32. Pourat N, Hadler M. Ready for ACA? How community health centers are preparing for health care reform. *Policy Brief UCLA Cent Health Policy Res*. 2014;(PB2014-4):1-6, appendix.
33. Hill SC, Zuvekas SH, Zodet MW. Implications of the accuracy of MEPS prescription drug data for health services research. *Inquiry*. 2011;48(3):242-59.

APPENDIX A Univariate and Multivariate Results of Process Measures of Diabetes Care

	OR (95% CI)	
	Univariate	Multivariate
Outcome: overall process measures of diabetes care^a		
Patient-centered medical homes (yes vs. no)	1.39 (0.94-2.07)	1.42 (1.06-1.91)
Age category		
Aged ≥ 65 years (vs. aged 18-44 years)	2.21 (1.45-3.37)	1.08 (0.77-1.50)
Aged 45-64 (vs. aged 18-44 years)	1.94 (1.23-3.04)	1.08 (0.76-1.53)
Male (vs. female)	0.97 (0.76-1.24)	0.91 (0.73-1.13)
Race/ethnicity		
Hispanic (vs. white)	0.51 (0.39-0.65)	0.59 (0.46-0.77)
Black (vs. white)	0.53 (0.41-0.68)	0.58 (0.46-0.73)
Asian/others (vs. white)	0.58 (0.36-0.94)	0.61 (0.40-0.95)
Education		
College or more (vs. lower than high school)	0.98 (0.73-1.33)	1.25 (0.96-1.63)
High school (vs. lower than high school)	1.79 (1.35-2.37)	1.77 (1.38-2.28)
Perceived health		
Excellent/very good (vs. fair/poor)	1.18 (0.78-1.79)	1.37 (0.97-1.92)
Good (vs. fair/poor)	1.55 (1.21-1.98)	1.50 (1.19-1.89)
Years of diabetes		
> 10 years (vs. < 5 years)	2.36 (1.72-3.25)	2.64 (1.99-3.50)
5-10 years (vs. < 5 years)	1.38 (0.96-1.98)	1.48 (1.05-2.09)
Not available (vs. < 5 years)	0.85 (0.33-2.19)	0.65 (0.26-1.62)
Elixhauser comorbidity score	1.03 (1.01-1.05)	1.02 (1.00-1.04)
Depression (yes vs. no)	0.78 (0.56-1.09)	0.88 (0.68-1.15)
Outcome: each process measure of diabetes care		
A1c test	1.02 (0.73-1.43)	1.04 (0.78-1.39)
Cholesterol test	1.18 (0.75-1.84)	0.96 (0.64-1.42)
Diabetes foot examination	1.39 (0.94-2.06)	1.21 (0.84-1.75)
Dilated eye examination	1.51 (1.05-2.18)	1.49 (1.08-2.05)
Flu vaccination	1.13 (0.77-1.65)	1.14 (0.80-1.61)

^a“Yes” for all process measures of diabetes care considered optimal diabetes care.

CI=confidence interval; OR=odds ratio.

APPENDIX B Univariate and Multivariate Results of Adherence to OHAs

	OR (95% CI)	
	Univariate	Multivariate
Outcome: adherence to OHAs		
Patient-centered medical homes (yes vs. no)	0.90 (0.62-1.31)	0.87 (0.58-1.30)
Age category		
Aged ≥65 years (vs. aged 18-44 years)	1.82 (1.22-2.72)	1.74 (1.15-2.63)
Aged 45-64 years (vs. aged 18-44 years)	1.85 (1.23-2.79)	1.77 (1.17-2.67)
Male (vs. female)	0.99 (0.77-1.29)	1.00 (0.77-1.29)
Race/ethnicity		
Hispanic (vs. white)	0.90 (0.68-1.19)	0.93 (0.68-1.28)
Black (vs. white)	0.77 (0.59-1.00)	0.77 (0.58-1.04)
Asian/others (vs. white)	0.77 (0.52-1.13)	0.76 (0.50-1.14)
Education		
College or more (vs. lower than high school)	1.03 (0.75-1.41)	0.90 (0.65-1.25)
High school (vs. lower than high school)	0.92 (0.66-1.27)	0.94 (0.67-1.32)
Perceived health		
Excellent/very good (vs. fair/poor)	0.90 (0.61-1.35)	0.87 (0.57-1.33)
Good (vs. fair/poor)	0.93 (0.71-1.23)	0.92 (0.69-1.22)
Years of diabetes		
> 10 years (vs. < 5 years)	1.26 (0.93-1.69)	1.18 (0.87-1.61)
5-10 years (vs. < 5 years)	1.40 (1.00-1.94)	1.33 (0.94-1.87)
Not available (vs. < 5 years)	1.49 (0.65-3.42)	1.49 (0.64-3.49)
Elixhauser comorbidity score	1.00 (0.97-1.02)	0.99 (0.97-1.02)
Depression (yes vs. no)	1.15 (0.83-1.59)	1.07 (0.74-1.55)
Number of OHA classes at baseline		
2 (vs. 1)	1.17 (0.90-1.51)	1.12 (0.84-1.50)
3 or more (vs. 1)	0.89 (0.55-1.45)	0.81 (0.49-1.34)
Baseline OHA copayment amount		
\$13-\$44 (vs. < \$13)	1.56 (1.13-2.16)	1.58 (1.12-2.23)
\$45-\$112 (vs. < \$13)	1.80 (1.30-2.48)	1.81 (1.30-2.52)
≥ \$113 (vs. < \$13)	1.52 (1.08-2.15)	1.45 (1.02-2.07)
≥ 1 brand-name OHA use (yes vs. no) ^a	0.90 (0.69-1.17)	–

^aThis variable was not included in the multivariate analysis due to multicollinearity.

CI = confidence interval; OHA = oral hypoglycemic agent; OR = odds ratio.