

Outcomes Among Chronically Ill Adults in a Medical Home Prototype

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Objectives: To compare quality, utilization, and cost outcomes for patients with selected chronic illnesses at a patient-centered medical home (PCMH) prototype site with outcomes for patients with the same chronic illnesses at 19 nonintervention control sites.

Study Design: Nonequivalent pretest-posttest control group design.

Methods: PCMH redesign results were investigated for patients with preexisting diabetes, hypertension, and/or coronary heart disease. Data from automated databases were collected for eligible enrollees in an integrated healthcare delivery system. Multivariable regression models tested for adjusted differences between PCMH patients and controls during the baseline and follow-up periods. Dependent measures under study included clinical processes and, outcomes, monthly healthcare utilization, and costs.

Results: Compared with controls over 2 years, patients at the PCMH prototype clinic had slightly better clinical outcome control in coronary heart disease (2.20 mg/dL lower mean low-density lipoprotein cholesterol; $P < .001$). PCMH patients changed their patterns of primary care utilization, as reflected by 86% more secure electronic message contacts ($P < .001$), 10% more telephone contacts ($P = .003$), and 6% fewer in-person primary care visits ($P < .001$). PCMH patients had 21% fewer ambulatory care-sensitive hospitalizations ($P < .001$) and 7% fewer total inpatient admissions ($P = .002$) than controls. During the 2-year redesign, we observed 17% lower inpatient costs ($P < .001$) and 7% lower total healthcare costs ($P < .001$) among patients at the PCMH prototype clinic.

Conclusions: A clinic-level population-based PCMH redesign can decrease downstream utilization and reduce total healthcare costs in a subpopulation of patients with common chronic illnesses.

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For author information and disclosures, see end of text.

Many stakeholders in American healthcare have embraced the patient-centered medical home (PCMH) in recent years. A variety of small and large practices¹ and delivery systems^{2,3} are implementing pilots and demonstration projects, with financial and operational support from payers⁴⁻⁶ and multistakeholder collaboratives.⁷ Although each medical home initiative reflects a unique blend of clinicians, patients, practice infrastructures, and payment mechanisms, all PCMH interventions have the goal of providing patients with a continuous source of whole-person primary care.⁸⁻¹⁰

Most PCMH interventions emphasize mechanisms to improve care delivery for persons with chronic illness. Chronically ill patients have long been hypothesized to benefit from PCMH elements such as team-based care, productive patient-provider relationships, clinical information technology use, and delivery system design.¹¹ The chronic care model has been incorporated in PCMH interventions¹² and assessment tools,¹³ and PCMH interventions have disproportionately targeted chronically ill patients¹⁴ or elderly patients with high chronic illness burdens.³

Despite these links between the medical home and chronic illness care, the evidence base contains few, if any, rigorous evaluations of PCMH effects on the quality, utilization, and costs of care in patients with chronic illnesses. We address this gap by reporting findings of a 2007 to 2008 prototype PCMH redesign² among patients with at least 1 of 3 common chronic illnesses in which the majority of care is typically delivered in the primary care setting: diabetes, hypertension, and coronary heart disease (CHD). Our objective in conducting this study was to investigate differences in quality, utilization, and costs of care between chronically ill patients at the PCMH site and comparable patients at 19 nonintervention control sites in the same healthcare system.

MEDICAL HOME PROTOTYPE

We assessed the impact of a PCMH redesign implemented at 1 clinic within Group Health, an integrated health plan and care delivery system in Washington State. The PCMH prototype clinic is located in metropolitan Seattle and is one of 20 clinics Group Health owns and operates in Washington's Puget Sound region. The clinic was chosen as the PCMH prototype because of the stability of its leadership and its history of successfully implementing change. Group Health pursued the PCMH redesign af-

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ter a series of reforms in financing and primary care operations yielded mixed results.¹⁵ Although the earlier reforms achieved their primary objectives of increasing patient access and satisfaction with care and reducing total costs, discouraging trends (eg, increased emergency department [ED] costs, decreased job satisfaction among primary care physicians) were also observed.¹⁶

A comprehensive list of design principles and change components in the PCMH redesign is presented elsewhere,¹² but we describe selected key elements here. In the prototype clinic, increased primary care staffing supported reductions in physicians' patient panels from an average of 2327 patients to 1800 patients, physicians were paired in dyads with medical assistants, and standard in-person primary care office visits were lengthened from 20 to 30 minutes. "Virtual medicine" contacts—secure electronic messaging and telephone encounters—were emphasized by encouraging patients to register for a secure online patient portal and by rerouting patients' calls to an organizational consulting nurse service to primary care teams during normal clinic operating hours. Some PCMH components explicitly targeted chronically ill patients,² such as creation of collaborative care plans and provider outreach (by phone or secure message) to manage monitoring tests.

Prior analyses compared 2-year outcomes for patients at the PCMH prototype clinic with those for patients at other Group Health clinics in western Washington State.^{2,17} In both the full practice and the practice's elderly subpopulation, PCMH patients had fewer ambulatory care–sensitive hospital admissions (13% full practice, 18% elderly) and fewer combined ED and urgent care visits (29% full practice, 21% elderly). Six percent fewer all-cause hospitalizations and accompanying lower inpatient costs (\$14 per month) were also observed in the full practice.²

METHODS

Study Design and Population

This study used a nonequivalent pretest-posttest control group design,¹⁸ including baseline data from 2006 and follow-up data from 2007 and 2008. We used automated Group Health databases to identify adults with diabetes mellitus (types 1 and 2), hypertension, or CHD. These data sources contain diagnoses, procedures, and pharmacy data for care obtained at Group Health and at sites where providers deliver care to Group Health patients on a contracted basis; laboratory results and clinical encounter data are only available for care provided at

Take-Away Points

This study investigated healthcare quality, utilization, and costs among patients with common chronic illnesses in a clinic-level, population-based patient-centered medical home (PCMH) prototype redesign during 2007 and 2008. Multivariable regression models tested for adjusted differences between PCMH patients and controls during baseline and follow-up periods.

- PCMH patients had 7% lower total healthcare costs during the 2-year redesign, largely driven by lower inpatient utilization and costs.
- PCMH patients with coronary heart disease had slightly better low-density lipoprotein cholesterol control.
- Findings demonstrate the capacity of a population-based PCMH redesign to achieve desirable outcomes in a chronically ill patient subpopulation.

Group Health. The accuracy and completeness of these data sources have been extensively validated.¹⁹⁻²² Group Health's institutional review board approved all study protocols.

Patients in the final study population were aged 18 to 85 years, received care at 1 of 20 Group Health clinics in western Washington State, had at least 6 months of enrollment during 2006, and had 3 or more months of enrollment in both 2007 and 2008. We also required enrollment during December 2006, which facilitated collection of baseline case mix variables.²³ To account for clinic-level factors and ensure comparability across study groups, we excluded patients who switched enrollment between clinics on a year-to-year basis. We excluded patients with dementia at baseline and women who gave birth during the study, as much of their healthcare use was presumably attributable to factors external to the PCMH redesign.

Patients at both the PCMH clinic and other clinics were only included in the final study population if they had 1 or more of the 3 included chronic illnesses. We identified patients with preexisting diabetes, hypertension, and CHD using case definitions designed to achieve high specificity and high positive predictive value.^{24,25} This approach utilized patterns of diagnoses, procedures, laboratory values, and pharmacy fills to minimize erroneous inclusion of "false positive" patients with unconfirmed chronic illness. Case definitions are listed in [Appendix A](#).

Data Collection and Measures

We collected data on disease-specific quality of care in the years 2006 and 2008. Laboratory results provided glycosylated hemoglobin (A1C) levels for patients with diabetes and low-density lipoprotein (LDL) cholesterol levels for patients with CHD. Systolic and diastolic blood pressure readings for patients with hypertension were acquired from electronic encounter data. If patients had clinical outcome data collected more than once in an individual year, we only used the last recorded value from that year.

Laboratory and blood pressure data were converted into disease-specific dependent variables for 3 types of quality

measures: clinical processes, clinical outcome benchmarks, and mean clinical outcomes. We created binary measures of clinical process performance based on whether laboratory data on A1C and LDL were collected annually. Outcome benchmarks were assessed by binary measures of A1C below 9.0% among patients with diabetes, blood pressure below 140/90 mm Hg among patients with hypertension, and LDL below 100 mg/dL among patients with CHD. Continuous A1C, systolic blood pressure, and LDL cholesterol results provided mean clinical outcome measures for each chronic illness.

Utilization and cost data were collected for the 2006 baseline year and the 2-year PCMH redesign. Group Health's automated systems assigned patient costs on a monthly basis, reporting actual costs from the general ledger. Overhead costs (eg, additional staffing costs during the PCMH redesign) were fully allocated to patient care departments. Cost and in-person utilization data were collected for primary care, specialty care, total inpatient admissions, and combined ED and urgent care. We also collected data on ambulatory care-sensitive inpatient utilization²⁶ and total healthcare costs. Clinical databases provided data on patients' use of secure message threads, telephone encounters, and calls to the consulting nurse service. We accounted for changes in internal cost accounting at Group Health during fall 2008 by truncating collection of cost and in-person utilization data at 21 months, which ensured consistency in these variables over time. Period-specific utilization and costs were converted to monthly rates based on patients' number of days of enrollment at Group Health during the baseline and PCMH redesign.

We collected data on patients' age, sex, and case mix variables from Johns Hopkins Adjusted Clinical Groups (ACG) System software.²³ Aggregated Diagnosis Groups variables from December 2006 provided a measure of patients' morbidity burden during the 2006 baseline year. The 32 Aggregated Diagnosis Groups variables classify *International Classification of Diseases, Ninth Revision* diagnoses into clinically cogent morbidity clusters based on duration, severity, diagnostic certainty, etiology, and expected need for specialty care, and have been extensively used for case mix ascertainment and adjustment in primary care populations.²⁷⁻²⁹

Analysis

Multivariable regression models assessed differences between PCMH patients and controls during the 2006 baseline year and the 2007 to 2008 follow-up periods. Each model tested for the effect of the PCMH by including a patient-level indicator of empanelment at the PCMH prototype clinic as the independent variable.

Quality-of-care analyses used data from the 2006 baseline year and 2008 to investigate differences between PCMH patients and controls with respect to condition-specific processes and outcomes. All patients with diabetes and CHD were included in the clinical process analysis; the clinical outcomes analysis for each chronic illness was restricted to patients who had disease-specific outcome data collected in both 2006 and 2008. We used Poisson regression models (Poisson distribution, log link) to investigate clinical processes and outcome benchmarks in the 2006 baseline year and the 2008 follow-up year, incorporating robust variance estimates to obtain relative risks.³⁰ We used linear regression models to investigate differences in mean clinical outcomes in 2006 and 2008. Each condition-specific regression model was restricted to patients with the targeted chronic illness, and adjusted for age and sex. Regression models estimating 2008 results additionally adjusted for 2006 baseline results.

Our analysis of healthcare use investigated rates of monthly in-person contacts and virtual medicine use during the 2006 baseline, the redesign's first year (2007), and the full observation period (in-person utilization analysis was truncated at 21 months). We used Poisson regression models to estimate utilization rates, setting the scale parameter to the deviance divided by the residual degrees of freedom to preclude violations of model assumptions of over- or under-dispersion.³¹ Regression models estimating baseline healthcare use adjusted for age and sex. Regression models estimating use during the PCMH redesign adjusted for age, sex, Aggregated Diagnosis Groups count, and binary indicators for each of the 3 chronic illnesses.

We used an algorithm recommended by Manning and Mullahy³² to select models for cost outcomes that would provide unbiased estimates of covariate effects in right-skewed monthly cost data. This approach led us to select a generalized linear regression model with log link and gamma distribution and to report results in proportional—rather than dollar-based—cost differences. Regression models estimating baseline year costs were adjusted for age and sex. Regression models estimating PCMH redesign period costs were adjusted for age, sex, and log-transformed baseline costs for each dependent cost variable (eg, inpatient cost models adjusted for log-transformed baseline inpatient costs).

All regression models investigating quality, utilization, and cost in the chronically ill study population were estimated using generalized estimating equations with independent working correlations and robust sandwich variance estimates.³³ This approach controlled for clustering at the level of patients' paneled primary care clinics and is robust to misspecification of within-cluster correlation. Analyses were conducted using SAS software, version 9.2 (SAS Institute Inc, Cary, North

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■ **Table 1.** Patient Characteristics at the PCMH Prototype Clinic and 19 Comparison Clinics at the Beginning of the PCMH Redesign (January 1, 2007)

Characteristic	PCMH Prototype (n = 1181)	Other Clinics (n = 36,757)	P
Age, y, mean (SD)	65.0 (11.8)	61.9 (11.9)	<.001
Age group, y, n (%)			
18-34	17 (1)	533 (1)	<.001
35-44	31 (3)	2093 (6)	
45-54	155 (13)	7196 (19)	
55-64	361 (31)	12,070 (33)	
65-74	339 (29)	8746 (24)	
75-85	278 (23)	6119 (17)	
Female, n (%)	642 (54)	18,850 (51)	.04
Chronic illnesses, n (%)			
Diabetes	421 (36)	14,913 (41)	<.001
Hypertension	798 (68)	25,858 (70)	.04
Coronary heart disease	139 (12)	5051 (14)	.05
Number of chronic illnesses (range: 1-3), n (%)			
1	1024 (87)	28,842 (79)	<.001
2	137 (11)	6765 (18)	
3	20 (2)	1150 (3)	
Count of healthcare conditions (ACG ADG), mean (SD)	7.2 (4.1)	6.9 (4.1)	.01

ACG indicates Adjusted Clinical Groups; ADG, Aggregated Diagnosis Groups; PCMH, patient-centered medical home; SD, standard deviation.

Carolina). We used an alpha threshold of $P \leq .05$ to determine the statistical significance of findings.

We conducted multiple sensitivity analyses to assess whether cost and utilization results were robust across analytic approaches. When assessing stability of 12- and 21-month cost and utilization results, 1 sensitivity analysis included patients with asthma and chronic obstructive pulmonary disease (COPD). These patients were initially targeted for inclusion but were excluded from the final study population due to low prevalence at the PCMH clinic and unavailability of disease-specific quality outcome data. A utilization-only sensitivity analysis by using DxCG risk scores mimicked the risk adjustment approach of prior PCMH prototype analyses.^{2,17,34} An additional sensitivity analysis used a difference-in-difference approach, adjusting for age and sex, to assess potential variability of utilization and cost findings for the full follow-up period.

RESULTS

The final study population included 37,938 adults with diabetes, hypertension, and/or CHD, with 1181 patients paneled to the PCMH prototype clinic and 36,757 patients paneled to other clinics (Table 1). On average, PCMH patients were 3.1 years older than patients at other clinics (mean age

65.0 vs 61.9 years; $P < .001$) and more likely to be female (54% vs 51%; $P = .04$). Patients at the PCMH clinic were less likely to have comorbid combinations of diabetes, hypertension, and CHD (13% vs 21%; $P < .001$), but had higher counts of Aggregated Diagnosis Groups case mix variables (mean 7.2 vs 6.9; $P = .01$), reflecting a greater prevalence of health conditions other than the 3 conditions targeted in this study. Among patients at both the PCMH prototype clinic and control clinics, 93% were enrolled at Group Health for the entire 2-year follow-up period.

Quality-of-care analysis revealed differences between the PCMH clinic and control clinics (Table 2). During the 2006 baseline year, patients with diabetes at the PCMH clinic were 4% more likely to have A1C under 9.0% ($P < .001$) and their mean A1C was 0.20% lower than that of the controls ($P < .001$). These differences among patients with diabetes largely persisted through the PCMH redesign. Although we observed no significant differences in LDL control among patients with CHD during baseline, in 2008 patients at the PCMH clinic were 11% more likely to have LDL below 100 mg/dL, ($P < .001$), and their mean LDL cholesterol was 2.20 mg/dL lower than that of the controls ($P < .001$). Patients with hypertension at the PCMH clinic were 5% more likely than controls to have blood pressure below 140/90 mm Hg

■ **Table 2.** Comparison of Disease-Specific Quality of Care at the PCMH Prototype Clinic and 19 Comparison Clinics During the 2006 Baseline Year and 2008 Follow-up Year

	No.	2006 Baseline ^a		2008 Follow-up ^b	
		Measure Met, %	Adjusted RR ^c (95% CI)	Measure Met, %	Adjusted RR ^c (95% CI)
Clinical processes					
DM: A1C testing					
PCMH clinic	421	90	1.00 (0.99-1.00)	86	1.01 (1.00-1.02) ^d
Other clinics	14,913	90	—	85	—
CHD: LDL screening					
PCMH clinic	139	86	1.01 (1.00-1.02)	82	1.00 (0.98-1.02)
Other clinics	5051	84	—	81	—
Clinical outcome benchmarks^e					
DM: A1C <9.0%					
PCMH clinic	343	89	1.04 (1.03-1.05) ^f	90	1.03 (1.02-1.03) ^f
Other clinics	11,902	86	—	86	—
HTN: BP <140/90 mm Hg					
PCMH clinic	713	58	1.05 (1.01-1.09) ^d	65	1.01 (0.98-1.05)
Other clinics	22,823	55	—	64	—
CHD: LDL <100 mg/dL					
PCMH clinic	106	70	1.01 (0.99-1.03)	84	1.11 (1.08-1.14) ^f
Other clinics	3638	69	—	75	—
Clinical outcomes ^e		2006 Baseline ^a		2008 Follow-up ^b	
		Mean	Adjusted Difference ^g (95% CI)	Mean	Adjusted Difference ^g (95% CI)
DM: A1C (%)					
PCMH clinic	343	7.22	-0.20 (-0.24 to -0.15) ^f	7.20	-0.15 (-0.18 to -0.13) ^f
Other clinics	11,902	7.44	—	7.51	—
HTN: systolic BP (mm Hg)					
PCMH clinic	713	136.3	-0.07 (-1.15 to 1.02)	133.3	-0.43 (-1.13 to 0.28)
Other clinics	22,823	136.1	—	133.5	—
CHD: LDL (mg/dL)					
PCMH clinic	106	90.5	-0.36 (-1.30 to 0.57)	84.9	-2.20 (-2.92 to -1.49) ^f
Other clinics	3638	90.7	—	87.3	—

A1C indicates glycated hemoglobin; BP, blood pressure; CHD, coronary heart disease; DM, diabetes mellitus; HTN, hypertension; LDL, low-density lipoprotein; PCMH, patient-centered medical home; RR, relative risk.

^aRegression models estimating 2006 baseline results adjusted for age and sex.

^bRegression models estimating 2008 results adjusted for age, sex, and 2006 baseline result.

^cAdjusted relative risks from Poisson regressions (Poisson distribution, log link) estimated using generalized estimating equations (independent working correlations, robust variance).

^d $P < .05$.

^eRestricted to patients with each chronic illness and outcome data collected in both 2006 and 2008.

^f $P < .001$.

^gAdjusted differences from linear regressions estimated using generalized estimating equations (independent working correlations, robust variance).

during baseline ($P = .01$), but we observed no differences in blood pressure control in 2008.

During the pre-PCMH baseline year, patients at the PCMH clinic had higher rates of specialty care visits (10%, $P < .001$), ambulatory care-sensitive hospitalizations (31%,

$P < .001$), and total inpatient admissions (22%, $P < .001$) compared with controls (Table 3). Baseline period differences in inpatient care were reversed during the first year of PCMH redesign—patients at the PCMH clinic had 23% fewer ambulatory care-sensitive hospitalizations ($P < .001$)

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■ Table 3. Comparison of Healthcare Use at the PCMH Prototype Clinic and 19 Comparison Clinics Over Baseline Period, 12 Months, and the Full Follow-up Period^a

Type of Utilization	Adjusted Rate Ratio (95% CI)		Adjusted Rate Ratio (95% CI)		Adjusted Rate Ratio (95% CI)	
		<i>P</i>		<i>P</i>		<i>P</i>
In-person contacts (monthly): PCMH prototype clinic vs other clinics	January 2006–December 2006 (Pre-PCMH Baseline)^b		January 2007–December 2007 (12 Months)^c		January 2007–September 2008 (21 Months)^c	
Primary care	1.02 (0.98-1.05)	.37	0.98 (0.95-1.00)	.06	0.94 (0.91-0.97)	<.001
Specialty care	1.10 (1.05-1.14)	<.001	1.04 (0.99-1.08)	.11	1.02 (0.98-1.07)	.32
ED/urgent care	0.82 (0.72-0.94)	.005	0.71 (0.63-0.81)	<.001	0.69 (0.61-0.79)	<.001
Ambulatory care–sensitive inpatient	1.31 (1.16-1.47)	<.001	0.77 (0.68-0.89)	<.001	0.79 (0.72-0.87)	<.001
All inpatient admissions	1.22 (1.16-1.28)	<.001	0.96 (0.92-1.00)	.05	0.93 (0.89-0.98)	.002
Virtual medicine contacts (monthly): PCMH prototype clinic vs other clinics	January 2006–December 2006 (Pre-PCMH Baseline)^b		January 2007–December 2007 (12 Months)^c		January 2007–December 2008 (24 Months)^c	
Secure message threads	1.12 (1.00-1.26)	.05	1.94 (1.79-2.11)	<.001	1.86 (1.71-2.02)	<.001
Telephone encounters	1.07 (1.02-1.12)	.01	1.17 (1.10-1.24)	<.001	1.10 (1.03-1.18)	.003
Consulting nurse calls	1.09 (1.04-1.14)	<.001	0.82 (0.76-0.88)	<.001	0.78 (0.73-0.83)	<.001

CI indicates confidence interval; ED, emergency department; PCMH, patient-centered medical home.
^aAdjusted rate ratios obtained from Poisson regression models (Poisson distribution, log link) correcting for over- or under-dispersion, estimated using generalized estimating equations with independent working correlations and robust variance.
^bRegression models estimating baseline healthcare use adjusted for age and sex only.
^cRegression models estimating healthcare use during the PCMH redesign adjusted for age, sex, a count of Aggregated Diagnosis Group measures, and indicators for diabetes, coronary heart disease, and hypertension.

and 4% fewer total inpatient admissions ($P = .05$) than controls—and these differences were sustained over 21 months. Patients at the PCMH clinic had fewer ED and urgent care contacts than controls during the baseline period (18%, $P = .005$); this difference widened to 29% over the first year of the PCMH redesign ($P < .001$) and 31% over 21 months ($P < .001$). Patients at the PCMH prototype clinic had 6% fewer in-person primary care contacts than controls ($P < .001$) over 21 months.

Patients at the PCMH prototype clinic had more virtual medicine contacts than controls during the pre-PCMH baseline year ($P \leq .05$). During the first 12 months of the redesign, PCMH patients had 94% more secure electronic message threads ($P < .001$) and 17% more telephone encounters than controls ($P < .001$). These differences were attenuated slightly in 24-month results ($P \leq .003$). The PCMH patients had 18% and 22% fewer telephone calls to the consulting nurse service over 12 and 24 months, respectively ($P < .001$ for both). This finding is consistent with the redesign's goal of decreasing

nonemergent consulting nurse calls by redirecting calls to the primary care team during clinic operating hours.¹²

Baseline cost findings were similar to observed baseline utilization results, including higher specialty care costs (32%, $P < .001$), lower ED and urgent care costs (16%, $P < .001$), and higher total inpatient costs (33%, $P < .001$) among patients at the PCMH clinic (Table 4). Despite nonsignificant differences in specialty utilization during the PCMH redesign, specialty care costs were 9% higher among PCMH patients over both 12 months ($P = .004$) and 21 months ($P = .02$). The PCMH patients had 6% lower ED and urgent care costs over 21 months ($P = .01$), 16% lower inpatient costs over 12 months ($P < .001$), and 17% lower inpatient costs over 21 months ($P < .001$). Total per member per month costs were 19% higher among PCMH patients during the baseline year ($P < .001$), but 8% lower over 12 months ($P < .001$) and 7% lower over 21 months ($P < .001$).

In sensitivity analyses using alternative inclusion criteria and case mix variables, findings for virtual medicine use and

■ **Table 4.** Comparison of Healthcare Costs at the PCMH Prototype Clinic and 19 Comparison Clinics Over Baseline Period, 12 Months, and 21 Months^a

MPPM Costs: PCMH Prototype Clinic vs Other Clinics	January 2006–December 2006 (Pre-PCMH Baseline) ^b		January 2007– December 2007 (12 Months) ^c		January 2007 – September 2008 (21 Months) ^c	
	Adjusted Cost Ratio (95% CI)	P	Adjusted Cost Ratio (95% CI)	P	Adjusted Cost Ratio (95% CI)	P
Primary care	1.00 (0.95-1.05)	.97	1.04 (0.99-1.09)	.11	1.01 (0.95-1.07)	.75
Specialty care	1.32 (1.23-1.43)	<.001	1.09 (1.03-1.15)	.004	1.09 (1.02-1.17)	.02
ED/urgent care	0.84 (0.77-0.92)	<.001	0.94 (0.87-1.01)	.08	0.94 (0.89-0.99)	.01
All inpatient admissions	1.33 (1.24-1.43)	<.001	0.84 (0.78-0.91)	<.001	0.83 (0.78-0.89)	<.001
Total MPPM costs	1.19 (1.16-1.22)	<.001	0.92 (0.90-0.95)	<.001	0.93 (0.90-0.96)	<.001

CI indicates confidence interval; ED, emergency department; PCMH, patient-centered medical home; MPPM, per member per month.
^aAdjusted cost ratios obtained from generalized linear models (gamma distribution, log link) estimated using generalized estimating equations with independent working correlations and robust variance.
^bRegression models estimating baseline costs adjusted for age and sex only.
^cRegression models estimating costs during the PCMH redesign adjusted for age, sex, and log-transformed 2006 baseline costs.

21-month in-person utilization and costs were robust across analytic approaches; selected 12-month findings varied by approach. When adjusting for DxCG variables or including patients with asthma and COPD (61 additional PCMH patients and 2340 additional controls) in 12-month analyses, we observed 5% greater specialty utilization among PCMH patients ($P = .05$ with DxCG adjustment; $P = .02$ including asthma and COPD) and no significant differences in all-cause inpatient admissions. Including patients with asthma and COPD also led to the observation of 7% higher primary care costs among PCMH patients at 12 months ($P = .003$).

The sensitivity analysis using a difference-in-difference approach estimated more dramatic savings among PCMH patients for inpatient costs and total healthcare costs. [Appendix B](#) presents complete difference-in-difference results and accompanying comments.

DISCUSSION

We observed numerous associations between a PCMH redesign and the quality, utilization, and costs of care among patients with diabetes, hypertension, and CHD. Patients at the PCMH clinic changed their primary care utilization patterns over the 2-year redesign, as reflected by use of more phone encounters and secure message threads, but fewer in-person primary care visits, than controls. Despite these changes, we observed no group-level differences in primary care costs, presumably due to the longer length of in-person visits at the PCMH site and costing systems' allocation of PCMH implementation costs to the prototype clinic. The PCMH patients had 9% higher specialty care costs during the redesign, which is smaller than the 32% greater specialty costs during the baseline year, but is consistent with prior findings.^{2,17}

Over 21 months, we observed reduced utilization of downstream care at the PCMH site, including less ED and urgent care, fewer ambulatory care-sensitive hospitalizations, and fewer total inpatient admissions. The PCMH patients had 7% lower total healthcare costs during the PCMH redesign, largely driven by the reversal of baseline year trends in inpatient use and costs. When applied to the \$697 unadjusted total monthly healthcare costs in this study population during the 2006 baseline year, the observed 7% cost difference translates to approximately \$49 savings per month.

Improved clinical outcome control among patients with CHD at the prototype clinic provides evidence of the PCMH's ability to globally reduce costs in this population while improving quality. Although differences in LDL cholesterol were statistically significant, they were small in magnitude, which is consistent with modest quality improvements observed in other PCMH transformations.³⁵

Our 2-year results on setting-specific utilization are comparable to those in other patient populations at the PCMH prototype clinic.^{2,17} We observed slightly greater differences between PCMH patients and controls for emergency and urgent care contacts, ambulatory care-sensitive hospitalizations, and total inpatient admissions. Given similar findings across analyses (eg, 7% fewer inpatient admissions among the chronically ill patients and 6% fewer among the full clinic population), we do not believe the impacts of the PCMH redesign were confined to patients with chronic illness. However, utilization impacts in chronologically ill patients were consistently larger than those in prior analyses, which probably contributed to the statistically significant lower total healthcare costs observed here, but not for all patients.²

This study differed from prior medical home evaluations in important ways. Unlike several PCMH interventions in the

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research literature,³⁶ Group Health's PCMH prototype redesign did not embed care managers in a primary care practice, nor was the intervention confined to a subgroup of high-risk or chronically ill patients. It was instead implemented in the prototype clinic's full patient population, incorporating fundamental tenets of primary care¹⁰ and chronic care³⁷ to support productive, longitudinal relationships between physician-led primary care teams and patients. Consistent with recommendations of a recent white paper commissioned by the Agency for Healthcare Research and Quality,³⁸ our study investigated PCMH effects among chronically ill patients and adjusted for clinic-level clustering.

Our encouraging findings were presumably attributable to an alignment of structures and processes at the PCMH clinic that allowed for effective provision of whole-person care. The PCMH components that may have facilitated the productive patient-provider interactions envisioned by the chronic care model¹¹ include enhanced care team staffing, pairing longer office visits with promotion of increased virtual medicine use, and effective outreach for patients' chronic and acute needs.

This study has several limitations, including a lack of patient-reported outcomes. As in all observational studies, observed associations do not necessarily represent causal effects. Incomplete control of confounding for socioeconomic, racial/ethnic, and other unmeasured characteristics may have obscured the true relationship between the PCMH redesign and study outcomes, and highly specific case definitions excluded patients with undiagnosed or untreated chronic illness. We were unable to definitively identify individual elements of the multicomponent redesign that were responsible for observed results.

A noteworthy limitation is the lack of generalizability due to nonrandom selection and implementation of a single-site PCMH redesign. The prototype clinic had a successful history of quality improvement compared with other clinics at Group Health, and its chronically ill patient population differed from the control population in important ways. Therefore, this prototype redesign may represent a best-case scenario with regard to potential cost impacts, motivation of clinical staff, and availability of organizational resources. Because the PCMH redesign was implemented in an integrated system with salaried providers, external validity for other primary care settings may be limited.

Study findings provide evidence of the capacity of a population-based medical home redesign to serve the needs of chronically ill patients. Changes in practice structures and care processes were associated with modest improvements in quality, less downstream utilization, and reduced healthcare costs. Cost reductions were observed within 1 year and persisted over the full study period. Future studies should investigate particularly effective elements of the PCMH care model,

the ability of treat-to-target protocols to achieve clinically meaningful changes in chronic care quality,^{22,39} and whether particular subgroups of chronically ill patients experience differentially large changes in quality, utilization, or costs.

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Outcomes Among Chronically Ill Adults

■ Appendix A. Case Definitions for Individual Chronic Illnesses

Chronic Illness	Case Definition
Diabetes (type 1 or 2)	<p>Adults aged 18-75 years who met ANY of the following during 2005-2006:</p> <ul style="list-style-type: none"> A) 2 outpatient diagnoses (<i>ICD-9 250.xx</i>) B) 1 inpatient diagnosis (<i>ICD-9 250.xx</i>) C) A1C test result $\geq 6.5\%$ D) During a 1-year period: <ul style="list-style-type: none"> 2 fasting glucoses ≥ 126 mg/dL OR 2 nonfasting glucoses ≥ 200 mg/dL OR 1 of each type of high-glucose reading E) Any filled prescription for insulin or oral diabetic agents <p>Exclusions: gestational diabetes (<i>ICD-9 648.8x</i>), polycystic ovarian disease (<i>ICD-9 256.4</i>)</p>
Hypertension	<p>Adults aged 18-85 years who met BOTH of the following during 2005-2006:</p> <ul style="list-style-type: none"> A) 2 diagnoses (<i>ICD-9 401.xx</i>) B) 2 filled prescriptions for antihypertensive medications
Coronary heart disease	<p>Adults aged 18-75 years who met ANY of the following during 2005-2006:</p> <ul style="list-style-type: none"> A) 2 diagnoses (any combination) of: <ul style="list-style-type: none"> Acute myocardial infarction (<i>ICD-9 410.xx</i>) Other acute and subacute forms of ischemic heart disease (<i>ICD-9 411.xx</i>) Old myocardial infarction (<i>ICD-9 412.xx</i>) Angina pectoris (<i>ICD-9 413.xx</i>) Other forms of chronic ischemic heart disease (<i>ICD-9 414.xx</i>) B) 1 <i>ICD-9</i> procedure code for: <ul style="list-style-type: none"> Percutaneous transluminal coronary angioplasty/atherectomy (00.66) OR Operations on vessels of heart (36.xx) C) 1 CPT code for a coronary vessel procedure: <ul style="list-style-type: none"> Coronary artery bypass graft (33510-33514, 33516-33523, 33533-33536); open coronary endarterectomy (33572); percutaneous transluminal coronary thrombectomy (92973); thrombolysis, coronary (92975, 92977); transcatheter placement of an intra coronary stent(s) (92980, 92981); coronary artery dilation (92982, 92984); coronary atherectomy (92995); coronary atherectomy add-on (92996)
<p>A1C indicates glycated hemoglobin; CPT, Current Procedural Terminology; <i>ICD-9</i>, <i>International Classification of Diseases, Ninth Revision</i>.</p>	

■ **Appendix B.** Comparison of Final Study Analysis (Adjusted 2-Year Differences) Results to Sensitivity Analysis (Difference-in-Difference) Results

Type of Utilization	PCMH Period Differences ^a		Difference-in-Difference		Comments: Final Study Analysis Vs Difference-in-Difference ^b
	Rate Ratio (95% CI)	P	Rate Ratio (95% CI)	P	
In-person contacts: PCMH clinic vs other clinics (21 months)					
Primary care	0.94 (0.91-0.97)	<.001	0.93 (0.89-0.97)	.001	Same inference across analytic approaches for all 2-year in-person utilization results
Specialty care	1.02 (0.98-1.07)	.32	0.92 (0.85-1.01)	.07	
ED/urgent care	0.69 (0.61-0.79)	<.001	0.85 (0.75-0.97)	.01	
Ambulatory care-sensitive inpatient	0.79 (0.72-0.87)	<.001	0.59 (0.37-0.94)	.03	
All inpatient admissions	0.93 (0.89-0.98)	.002	0.76 (0.62-0.92)	.006	
Virtual medicine use: PCMH clinic vs other clinics (24 months)					
Secure message threads	1.86 (1.71-2.02)	<.001	1.68 (1.53-1.85)	<.001	<i>Difference-in-difference: null findings</i>
Telephone encounters	1.10 (1.03-1.18)	.003	1.02 (0.96-1.08)	.48	
Consulting nurse calls	0.78 (0.73-0.83)	<.001	0.72 (0.66-0.79)	<.001	
PMPM costs: PCMH prototype clinic vs other clinics (21 months)					
	Cost Ratio (95% CI)	P	Cost Ratio (95% CI)	P	Comments: Final Study Analysis Vs Difference-in-Difference ^c
Primary care	1.01 (0.95-1.07)	.75	1.01 (0.96-1.07)	.74	<i>Difference-in-difference: savings in PCMH</i>
Specialty care	1.09 (1.02-1.17)	.02	0.87 (0.77-0.98)	.03	
ED/urgent care	0.94 (0.89-0.99)	.01	1.12 (0.91-1.37)	.29	<i>Final study analysis: higher costs in PCMH, but less high than baseline</i> <i>Difference-in-difference: null findings</i>
All inpatient admissions	0.83 (0.78-0.89)	<.001	0.66 (0.48-0.92)	.01	<i>Final study analysis: conservative compared with difference-in-difference</i>
Total PMPM costs	0.93 (0.90-0.96)	<.001	0.83 (0.72-0.96)	0.01	
CI indicates confidence interval; ED, emergency department; PCMH, patient-centered medical home; PMPM, per member per month. ^a Also presented in Table 3 in the study. ^b $\alpha = .05$. ^c Also presented in Table 4 in the study.					