Specialty Use Among Patients With Treated Hypertension in a Patient-Centered Medical Home

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BACKGROUND: Little is known about how delivery of primary care in the patient-centered medical home (PCMH) influences outpatient specialty care use.

OBJECTIVE: To describe changes in outpatient specialty use among patients with treated hypertension during and after PCMH practice transformation.

DESIGN: One-group, 48-month interrupted time series across baseline, PCMH implementation and post-implementation periods.

PATIENTS: Adults aged 18–85 years with treated hypertension.

INTERVENTION: System-wide PCMH redesign implemented across 26 clinics in an integrated health care delivery system, beginning in January 2009.

MAIN MEASURES: Resource Utilization Band variables from the Adjusted Clinical Groups case mix software characterized overall morbidity burden (low, medium, high). Negative binomial regression models described adjusted annual differences in total specialty care visits. Poisson regression models described adjusted annual differences in any use (yes/no) of selected medical and surgical specialties.

KEY RESULTS: Compared to baseline, the study population averaged 7 % fewer adjusted specialty visits during implementation ($P<0.001$) and 4 % fewer adjusted specialty visits in the first post-implementation year ($P=0.02$). Patients were 12 % less likely to have any cardiology visits during implementation and 13 % less likely during the first post-implementation year ($P<0.001$). In interaction analysis, patients with low morbidity had at least 27 % fewer specialty visits during each of 3 years following baseline ($P<0.001$); medium morbidity patients had 9 % fewer specialty visits during implementation ($P<0.001$) and 5 % fewer specialty visits during the first post-implementation year ($P=0.007$); high morbidity patients had 3 % ($P=0.05$) and 5 % ($P=0.009$) higher specialty use during the first and second post-implementation years, respectively.

CONCLUSIONS: Results suggest that more comprehensive primary care in this PCMH redesign enabled primary care teams to deliver more hypertension care, and that many needs of low morbidity patients were within the scope of primary care practice. New approaches to care coordination between primary care teams and specialists should prioritize high morbidity, clinically complex patients.

KEY WORDS: primary care redesign; patient centered care; health care delivery; specialty care; hypertension.
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INTRODUCTION

In recent years, the patient-centered medical home (PCMH)[1] has attracted attention as a potential solution to systemic deficiencies in American primary care.[2] As PCMH demonstrations are launched across the country and early findings are published,[3–5] the PCMH research agenda[6,7] has largely addressed whether this care model reduces emergency and inpatient use—and associated costs—or improves quality of care. Although researchers have posited that some tasks currently provided by specialists may be shifted to generalists in the medical home,[8,9] to our knowledge, no studies have investigated changes at the PCMH-specialty care interface.

The PCMH should enable primary care teams to deliver more comprehensive care for common conditions,[1] leading to potential decreases in outpatient specialty use for some patients. The PCMH promotes delivery of population-based care, facilitated by tools such as chronic illness registries, to support efforts to improve disease control and prevent downstream complications. When specialist expertise is needed to address patients' health care needs, care coordination between primary care teams and specialty practices should take place in a "medical neighborhood."[10,11] Specialty referrals may be clinically indicated for multiple reasons, including a lack of clear treatment guidelines in the presence of comorbid conditions[12] or rare conditions that specialists are better-equipped to treat.[13] Individuals with high morbidity burden or complex health care complaints should therefore continue to see specialists in the PCMH, but only when their clinical needs fall outside the purview of primary care providers' expertise.[14]

Prior studies of managed care[15] and Medicare populations[16] not exposed to the PCMH linked high overall morbidity burden with high specialty use. In addition, an analysis of Canadian patients with hypertension found an additive relationship between primary care contacts and specialty visits, particularly among individuals with high morbidity.[17] Taken together, these findings suggest that increased contact between patients and primary care teams in the PCMH could lead to additional specialty referrals for patients with high morbidity.

We conducted this study to improve our understanding of comprehensive primary care's impact on specialty use. We focus on specialty visits within the PCMH among patients with treated hypertension—a common chronic condition for which the majority of care is typically delivered in the primary care setting[18]—who received care before, during and following a 2009–2010 PCMH redesign in a large health care system. Our primary objective was to describe changes in total specialty use during and after PCMH practice transformation, and potential differences in observed changes according to level of overall morbidity burden. Our secondary objective was to describe changes in patients' likelihoods of visiting selected medical and surgical specialties.

Study Setting

This study took place at Group Health (GH), an integrated health plan and care delivery system in the Pacific Northwest. All GH clinics use the EpicCare electronic medical record (Epic Systems Corporation; Verona, WI). Six GH clinics have co-located specialty care services, though providers can refer patients to external specialists when needed.[19] GH undertook a PCMH redesign across its entire system of clinics between January 2009 and March 2010. The rollout of PCMH implementation was staggered between January and April 2009 (four groups across 26 clinics); each GH clinic underwent a yearlong PCMH implementation.[20]

Before transforming primary care across all clinics it owned and operated, GH tested a PCMH prototype redesign at one high-performing clinic during 2007–2008. The prototype redesign achieved several objectives, including improved performance on composite quality measures and reductions in inpatient and emergency/urgent care.[21]

GH's prototype redesign did not clearly demonstrate how the PCMH impacted specialty use. Chronically ill adults at the PCMH prototype clinic had 10 % higher adjusted specialty use, compared to controls, in the baseline year preceding the redesign. In the 2-year redesign, chronically ill PCMH patients had slightly higher adjusted specialty use than controls (4 % over the first year, 2 % over 2 years), but differences were not statistically significant.[22] These early results suggest the potential for the PCMH to reduce specialty use among the chronically ill, but multiple factors—such as non-random selection of the prototype clinic—limit our ability to draw general conclusions.

We expected that GH's system-wide PCMH redesign would enable primary care teams to deliver more accessible, comprehensive care to their patients. We expected these changes would lead to lower specialty use among less complex patients, but that more complex patients would not experience a reduction in specialty use.

METHODS

Study Design and Population

This study employed an interrupted time series design[23] using annual patient observation ("patient-year") as the unit of analysis. We collected data from the 4-year period between January 2008 and December 2011. We identified patients' first month of exposure to the care redesign by linking clinic-specific dates of PCMH initiation (between January and April 2009[20]) with enrollment data. Patient-years were then categorized according to four study years: pre-PCMH baseline (year zero), PCMH implementation (year one), the first post-implementation year (year two) and the second post-implementation year (year three). GH's institutional review board approved all study protocols.

The study population included continuously enrolled adults aged 18–85 years who were previously diagnosed and treated for hypertension. Individuals met our case definition for treated hypertension if during the 24 months before the baseline year they had: $\geq$ 2 International Classification of Diseases, Ninth Revision (ICD-9) hypertension diagnoses (401.xx); and $\geq$ 2 filled prescriptions for antihypertensive medications. Inclusion criteria were based on prior findings of high specificity and moderate sensitivity.[24]

We required continuous enrollment at GH during both the baseline year and the PCMH implementation year, which ensured receipt of at least 1 year of care within the PCMH redesign. We excluded 469 individuals with any ICD-9 diagnosis of end-stage renal disease (585.6, V45.1, V56.x), because GH dialysis patients are generally managed by nephrologists who not did transform their practices to the PCMH. We also excluded 159 women who gave birth during the study, due to the potential for pregnancy-related complications in chronic hypertension care and risks for preeclampsia.[25] Individuals were censored during the two post-implementation years due to death, aging out of the cohort, or disenrollment from GH.

Measures

Variables were collected from existing files originally created for an evaluation of the system-wide redesign among all GH patients.[19] Annual data on specialty use—visits to individual specialties, and counts of total specialty visits—were drawn from databases linked to automated costing systems that categorize outpatient specialty visits according to provider type. After extracting monthly counts of office visits, we summed monthly measures to patient-year totals.

We collected data on primary care "contacts"—in-person visits, telephone encounters and secure messaging threads (a secure messaging thread is an original electronic message, and all subsequent replies, sent through GH's secure online portal)[26]—and calculated total primary care contact rates by summing rates of all three encounter types. Because of the staggered PCMH implementation, individuals contributed between 9 and 12 months of data during the final patient-year concluding in December 2011. We annualized outpatient use totals for this period by multiplying observed counts by (12/X), where X represents the number of months enrolled.

Several potential confounding variables were collected, including age (18–44, 45–54, 55–64, 65–74, 75–85) and 12-month calendar interval of each patient-year (to adjust for secular trends). After linking monthly data on individuals' paneled primary care clinics with driving distances to the nearest of GH's six specialty care sites,[27] we created a measure of proximity to specialty care (co-located specialty care; ≤ 15 miles; > 15 miles). Using methods described elsewhere,[19] we created ecologic census tract-level measures of education (low, medium, high) and median household income (≤ $50,000; $50,001–60,000; $60,001–70,000; > $70,000). We classified insurance type as commercial, Medicare or Medicaid/state-subsidized, and collected data on plan generosity regarding provider choice (HMO vs. point-of-service plan), pharmaceutical coverage and waiver of copayment/cost sharing for well-care visits. Besides sex, all potential confounding variables were annual, time-varying measures.

We used several variables from the Johns Hopkins Adjusted Clinical Groups (ACG) System case mix software[28] to describe morbidity mix. Resource Utilization Band (RUB) variables from the first month of each patient-year classified individuals' overall morbidity burden on a six-point ordinal scale, from none to very high, based on groupings of all ICD-9 diagnoses from the previous 12 months.

We then defined three morbidity groups based on RUB overall comorbidity. Since the entire study population had hypertension, no included patients were classified in the two lowest RUB categories (none, healthy).[28] We recoded low RUB values to the moderate category for 532 individuals with comorbid diabetes who were not already assigned a RUB value of moderate or greater. We then used RUB data to divide the study population into three comorbidity burden groups: low (RUB = low), medium (RUB = moderate) and high (RUB = high or RUB = very high).

We separately created disease profiles for the study population during the baseline year by collecting all 269 Expanded Diagnosis Cluster (EDC) variables and all 27 Major EDC variables from ACG software. Unlike RUBs—which summarize overall morbidity burden—EDC variables present a complementary morbidity perspective based on organ system and pathophysiologic process.[29] EDCs are created by combining groups of individual diagnoses into a defined set of conditions (e.g., depression, gout). Major EDC variables separately map each EDC into one clinical category identifying the physician specialty most likely to provide care for that EDC (e.g., Parkinson's disease is one of 20 EDCs in the Neurologic Major EDC). The supplementary Appendix, which is available online, contains a list common EDCs in the study population (≥ 5 % prevalence).

After matching prevalent conditions from the baseline year to several relevant specialties, we collected binary measures (0/1) of whether patients made any annual visits to each of ten GH specialties: behavioral health (psychiatrists, psychologists, chemical dependency providers), cardiology, consultative internal medicine, eye care (optometrists and ophthalmologists), gastroenterology, general surgery, neurology, obstetrics/gynecology (females only), orthopedic surgery and urology. Other than consultative internal medicine, GH patients could self-refer to all specialties listed above.[30] Limitations in classification by Group Health databases precluded extraction of visit data for dermatology, nephrology, endocrinology and pulmonology.

Statistical Analysis

We described annual differences in adjusted total specialty visit rates by estimating two multivariable negative binomial regression models.[31] In both models, the outcome variable was the count of total specialty care visits during each patient-year. The key predictor was categorical study year (referent, baseline). The first negative binomial model described average findings across the study population; in the second model, morbidity group-by-year interactions tested whether annual differences in specialty use varied by morbidity burden group. We also conducted a sensitivity analysis, which examined whether year three enrollment length impacted total specialty visit rates, by estimating negative binomial regression models stratified by year three enrollment length (9–12 months).

We estimated Poisson regression models to describe the annual relative risk[32,33] of any visits to each of the ten specialties under study. We adjusted for exposure time using an offset term representing the number of months enrolled during each patient-year. The key independent variable was categorical study year (referent, baseline). These models did not include interactions.

All regression models adjusted for all potential confounding variables described above. We estimated regressions using generalized estimating equations (GEE), which accounted for longitudinal data clustered at the patient level using an independent working correlation matrix. "Sandwich" variance estimates were used to ensure models were robust to misspecification of within-cluster correlation.[34] Analyses were conducted using Stata, version 12 (College Station, TX).

RESULTS

The study population included 36,805 adults with treated hypertension who were age 18–85 years (mean 64.2, SD 11.9) at the beginning of year one (Table 1). Similar proportions of individuals had commercial insurance (48.8 %) or Medicare (49.9 %), while only 1.3 % had Medicaid or state-subsidized insurance. The population was 55.1 % female, 28.4 % had diabetes, and large majorities had an HMO network (91.2 %), a well-care waiver (80.8 %) and pharmaceutical coverage (89.1 %). Seventy-one percent lived in census tracts with median household incomes of at least $50,000, and 64.4 % lived in census tracts with medium or high education. High morbidity patients were notably older (mean age 67.8 years, SD 11.5) than low (mean 58.0, SD 11.1) and medium (mean 62.8, SD 11.6) morbidity patients. Included individuals contributed 138,136 patient-years (mean 3.8, range 2–4) to the analysis.

At the beginning of the baseline year (year zero), 7.2 % of individuals had low morbidity burden, as defined by the low category of the ACG RUB measure; the high morbidity group (high/very high RUB) contained 34.5 % of the study population (Fig. 1). The proportion of individuals in the medium morbidity group (moderate RUB) declined slightly over time, while proportions of individuals in the low and high morbidity groups increased slightly.

As observed previously,[21] rates of total primary care contacts increased in the PCMH transformation, largely driven by increased secure messaging and telephone use.

Table 1. Population Characteristics at Beginning of the PCMH Implementation Year (Year 1)

Population characteristics	Study population, No. (%)*	Morbidity burden group, No. (%)*		
		Low†	Medium†	High†
Total (*Row* %)	*36,805*	*2,770* (*7.5*)	*20,871* (*56.7*)	*13,164* (*35.8*)
Age, mean (SD)	64.2 (11.9)	58.0 (11.1)	62.8 (11.6)	67.8 (11.5)
Age group				
18–44	1,831 (5.0)	284 (10.2)	1,175 (5.6)	372 (2.8)
45–54	5,966 (16.2)	722 (26.1)	3,824 (18.3)	1,420 (10.8)
55–64	11,173 (30.4)	1,066 (38.5)	6,926 (33.2)	3,181 (24.2)
65–74	9,176 (24.9)	469 (16.9)	4,998 (24.0)	3,709 (28.2)
75–85	8,659 (23.5)	229 (8.3)	3,948 (18.9)	4,482 (34.0)
Female sex	20,294 (55.1)	1,321 (47.7)	11,600 (55.6)	7,373 (56.0)
Insurance segment				
Commercial	17,975 (48.8)	2,040 (73.7)	11,478 (55.0)	4,457 (33.8)
Medicaid/State-subsidized	474 (1.3)	51 (1.8)	308 (1.5)	115 (0.9)
Medicare	18,356 (49.9)	679 (24.5)	9,085 (43.5)	8,592 (65.3)
HMO provider network	33,565 (91.2)	2,393 (86.4)	18,816 (90.2)	12,356 (93.9)
Well-care waiver	29,730 (80.8)	2,160 (78.0)	16,746 (80.2)	10,824 (82.2)
Pharmaceutical coverage	32,806 (89.1)	2,493 (90.0)	18,706 (89.6)	11,607 (88.2)
Diabetes (Type 1 or 2)	10,462 (28.4)	0 (0.0)	5,720 (27.4)	4,742 (36.0)
Census tract education				
Low	13,089 (35.6)	974 (35.1)	7,517 (36.0)	4,598 (34.9)
Medium	11,786 (32.0)	877 (31.7)	6,576 (31.5)	4,333 (32.9)
High	11,930 (32.4)	919 (33.2)	6,778 (32.5)	4,233 (32.2)
Census tract median income				
≤$50,000	10,696 (29.0)	789 (28.5)	6,096 (29.2)	3,811 (29.0)
$50,001–$60,000	9,228 (25.1)	694 (25.0)	5,190 (24.9)	3,344 (25.4)
$60,001–$70,000	7,386 (20.1)	540 (19.5)	4,236 (20.3)	2,610 (19.8)
>$70,000	9,495 (25.8)	747 (27.0)	5,349 (25.6)	3,399 (25.8)
Proximity to specialty care				
Co-located with primary care	13,400 (36.4)	1,012 (36.5)	7,631 (36.6)	4,757 (36.1)
Near (< 15 miles by car)	16,506 (44.9)	1,276 (46.1)	9,479 (45.4)	5,751 (43.7)
Distant (> 15 miles by car)	6,899 (18.7)	482 (17.4)	3,761 (18.0)	2,656 (20.2)

Abbreviations: PCMH patient-centered medical home; SD standard deviation; ACG Adjusted Clinical Groups; RUB Resource Utilization Band; HMO health maintenance organization

**** Percentages for categorical variables based on column totals***

† *Time-varying morbidity burden defined by annual ACG RUB value: Low morbidity, RUB=Low; Medium morbidity, RUB=Moderate; High morbidity, RUB=High/Very high*

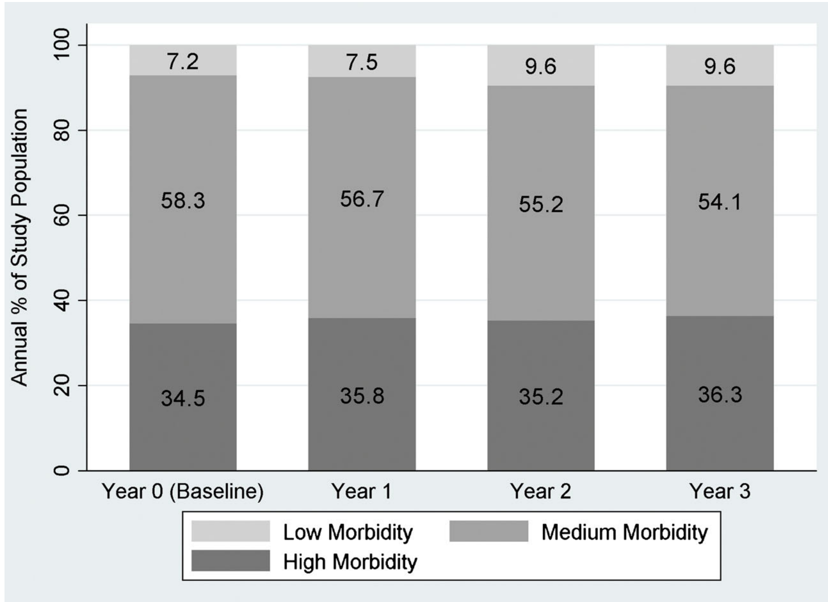

Figure 1. Percent of study population in low, medium and high morbidity burden groups during each year*. *Abbreviations*: *ACG* Adjusted Clinical Groups; *RUB* Resource Utilization Band. * Time-varying morbidity burden defined by annual ACG RUB value: Low morbidity, RUB = Low; Medium morbidity, RUB = Moderate; High morbidity, RUB = High/Very high.

Mean annual primary care contacts increased from 12.83 contacts (SD 12.91) during baseline to 15.73 contacts (SD 16.87) in year three, but mean in-person primary care use decreased from 3.78 (SD 3.55) visits during baseline to 3.26 (SD 3.70) visits in year three.

Although unadjusted specialty use increased over time in the full study population, changes varied across morbidity burden groups (Fig. 2). In low morbidity patients, mean unadjusted specialty use decreased from baseline to year one, and remained largely stable during the post-implemen-

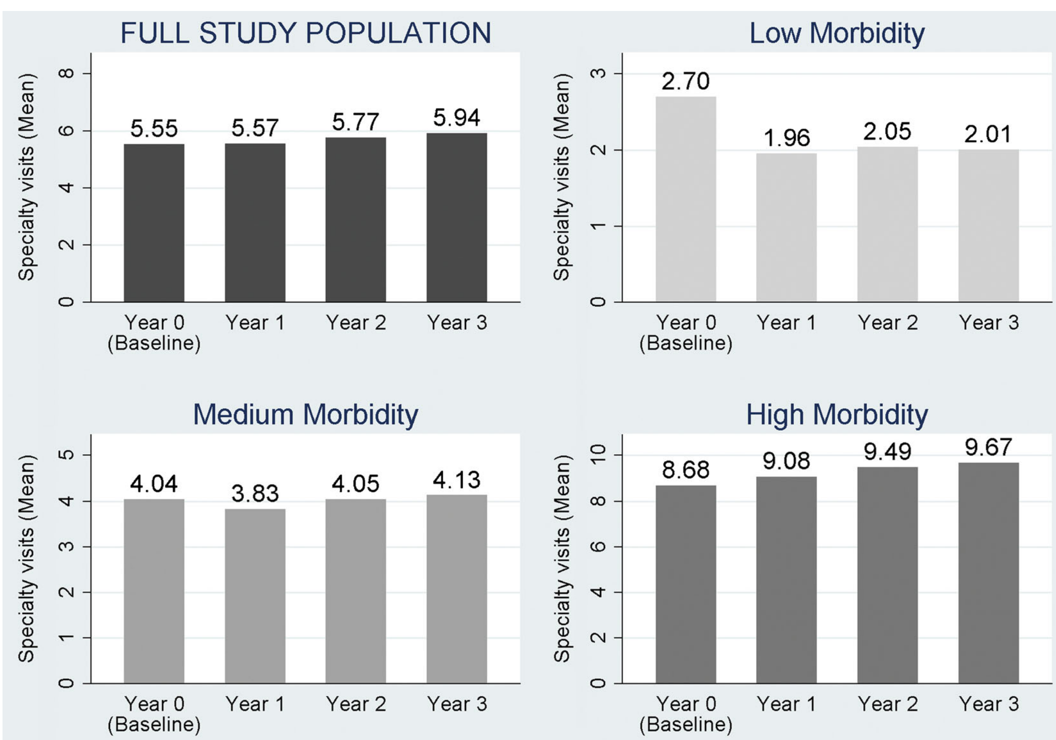

Figure 2. Annual total specialty care use (unadjusted) in full study population and in low, medium and high morbidity burden groups*. *Abbreviations*: *ACG* Adjusted Clinical Groups; *RUB* Resource Utilization Band. * Time-varying morbidity burden defined by annual ACG RUB value: Low morbidity, RUB = Low; Medium morbidity, RUB = Moderate; High morbidity, RUB = High/Very high.

tation years. In medium morbidity patients, mean specialty use fell from baseline to year one, but increased during years two and three. In high morbidity patients, specialty use increased annually.

Using a negative binomial regression model that adjusted for potential confounders, including morbidity burden, we estimated that total adjusted specialty use decreased during PCMH implementation and the first post-implementation year (Table 2). Compared to baseline, the study population averaged 7 % fewer total specialty visits in year one ($P<0.001$) and 4 % fewer total specialty visits in year two ($P=0.02$). We found no significant difference in total specialty use between baseline and year three.

A separate model estimating adjusted total specialty use, and including interaction effects, demonstrated substantial variation across RUB morbidity groups (Table 2). Low morbidity patients had 28 % fewer specialty visits during year one, 27 % fewer visits in year two and 28 % fewer visits in year three ($P<0.001$ for all), compared to baseline. Medium morbidity patients had 9 % lower specialty use during year one ($P<0.001$) and 5 % lower specialty use in year two ($P=0.007$). Conversely, high morbidity patients had 3 % *higher* specialty use in year two—this result approached statistical significance at $P<0.05$ ($P=0.052$)—and 5 % higher specialty use during year three ($P=0.009$).

Sensitivity analysis revealed no clear differences by higher or lower lengths of year three enrollment. Patients enrolled for 11 months during year three had 5 % fewer adjusted specialty visits, compared to year zero ($P=0.04$), but we observed no significant differences among individuals enrolled for 9, 10 or 12 months.

Individuals were less likely to visit some specialties during and after PCMH implementation (Table 3). During years one and two, the adjusted relative risk of visits to cardiology, consultative internal medicine and gastroenterology was reduced by ≥ 12 %; this decrease persisted through year three for consultative internal medicine and gastroenterology ($P<0.001$ for all). In year two, individuals had reduced relative risk of any visits to eye care (4 %, $P<0.001$) and general surgery (10 %, $P=0.010$). During year three, however, the study population was at least 8 % more likely to visit behavioral health, eye care, neurology and orthopedic surgery ($P<0.001$ for all).

DISCUSSION

Patients with treated hypertension experienced changes in specialty care use patterns in GH's system-wide PCMH redesign. On average, the redesign was associated with 2 years of modestly decreased adjusted specialty use, but there was substantial variation across morbidity burden groups. Low morbidity patients had a rapid and sustained decrease in specialty use, while specialty use patterns in medium morbidity patients mirrored those of the full study

Table 2. Results of Negative Binomial Regression Models Estimating Adjusted Annual Differences in Rates of Total Specialty Care Use

Adjusted analysis: specialty use rate*	Year	Adjusted rate ratio (95 % CI)	*P* value
Full study population	Year 0: Baseline§	1.00	N/A
	Year 1: PCMH Implementation	0.93 (0.91, 0.96)	< 0.001
	Year 2: 1st Post-Implementation Year	0.96 (0.94, 0.99)	0.02
	Year 3: 2nd Post-Implementation Year	0.98 (0.95, 1.01)	0.23
Adjusted analysis, with interactions: specialty use rate†	**Year**	**Adjusted rate ratio (95% CI)**	***P* value**
Low morbidity‡	Year 0: Baseline§	1.00	N/A
	Year 1: PCMH Implementation	0.72 (0.65, 0.78)	< 0.001
	Year 2: 1st Post-Implementation Year	0.73 (0.67, 0.80)	< 0.001
	Year 3: 2nd Post-Implementation Year	0.72 (0.66, 0.80)	< 0.001
Medium morbidity‡	Year 0: Baseline§	1.00	N/A
	Year 1: PCMH Implementation	0.91 (0.88, 0.95)	< 0.001
	Year 2: 1st Post-Implementation Year	0.95 (0.92, 0.99)	0.007
	Year 3: 2nd Post-Implementation Year	0.97 (0.93, 1.01)	0.14
High morbidity‡	Year 0: Baseline§	1.00	N/A
	Year 1: PCMH Implementation	1.00 (0.97, 1.04)	0.77
	Year 2: 1st Post-Implementation Year	1.03 (1.00, 1.07)	0.05‖
	Year 3: 2nd Post-Implementation Year	1.05 (1.01, 1.09)	0.009

Abbreviations: PCMH patient-centered medical home; ACG Adjusted Clinical Groups; RUB Resource Utilization Band; CI confidence interval

**** Results from negative binomial regression model describing average annual differences in total specialty visit rates and adjusting for the following potential confounders: sex, age, morbidity burden, diabetes, insurance characteristics, census tract-level income, census tract-level education, calendar period***

† Results represent linear combinations of coefficients from negative binomial regression model including morbidity group-by-year interactions and adjusting for potential confounders

‡ Time-varying morbidity burden defined by annual ACG RUB value: Low morbidity, RUB = Low; Medium morbidity, RUB = Moderate; High morbidity, RUB = High/Very high

§ Modeled referent category

‖ P= 0.052

Table 3. Results of Poisson Regression Models Estimating Adjusted Annual Relative Risks of Visits to Selected Medical and Surgical Specialties

Medical or surgical specialty*	Year 0: Baseline[§]	Year 1: PCMH Implementation	Year 2: 1st post-implementation year	Year 3: 2nd post-implementation year
	Any visits, n (%)	Adjusted RR (95 % CI)[‖]	Adjusted RR (95 % CI)[‖]	Adjusted RR (95 % CI)[‖]
Behavioral Health	2,666 (7.2)	1.02 (0.96, 1.08)	1.05 (0.98. 1.12)	**1.23 (1.14, 1.33)**[¶]
Cardiology	12,461 (33.9)	**0.88 (0.85, 0.91)**[¶]	**0.87 (0.84, 0.89)**[¶]	0.99 (0.95, 1.02)
Consultative Internal Medicine[†]	3,578 (9.7)	**0.70 (0.64, 0.77)**[¶]	**0.56 (0.51, 0.62)**[¶]	**0.61 (0.54, 0.68)**[¶]
Eye Care	1,7991 (48.9)	1.02 (1.00, 1.05)	**0.96 (0.94, 0.98)**[¶]	**1.08 (1.06, 1.11)**[¶]
Gastroenterology	5,354 (14.6)	**0.88 (0.83, 0.93)**[¶]	**0.82 (0.77, 0.87)**[¶]	**0.86 (0.81, 0.93)**[¶]
General Surgery	2,932 (8.0)	0.95 (0.88, 1.02)	**0.90 (0.84, 0.98)**	1.01 (0.93, 1.10)
Neurology	2,140 (5.8)	1.00 (0.91, 1.09)	1.06 (0.96, 1.16)	**1.24 (1.13, 1.37)**[¶]
Obstetrics/Gynecology[‡]	1,618 (8.0)	0.93 (0.85, 1.01)	0.98 (0.90, 1.08)	1.09 (0.98, 1.21)
Orthopedic Surgery	6,062 (16.5)	0.96 (0.92, 1.00)	0.96 (0.91, 1.01)	**1.11 (1.05, 1.17)**[¶]
Urology	2,626 (7.1)	0.98 (0.91, 1.05)	0.98 (0.91, 1.06)	1.04 (0.95, 1.13)

Abbreviations: PCMH patient-centered medical home; RR relative risk; CI confidence interval
**** Poisson regression models adjusted for exposure time, using an offset term representing the number of months enrolled during each patient-year, and adjusted for the following potential confounders: sex, age, morbidity burden, diabetes, insurance characteristics, census tract-level income, census tract-level education, calendar period***
† Physician referral required to see providers in this specialty
‡ Females only (n= 20,294). Full study population (N= 36,805) included in regression models for all other specialties listed in the table
§ Modeled referent category: relative risks for years 1, 2 and 3 are relative to year 0
‖ Boldface text in these columns indicates statistically significant results at P< 0.05
¶ P< 0.001

population. High morbidity patients—who were older than patients with low and medium morbidity—had higher specialty use during the two post-implementation years, though year two differences may have been due to chance.

We believe that low morbidity patients had fewer specialty visits in the PCMH because many of their needs were within the scope of primary care practice, which was characterized by greater staffing resources when reconfigured within the PCMH redesign.[20] We observed more specialist visits among high morbidity patients after implementation of comprehensive PCMH-based care. Although we did not investigate the clinical content of these additional visits, prior research[14] suggests they served as a venue for specialists to co-manage unstable chronic illnesses and provide advice on caring for common conditions that are resistant to conventional treatments. Additional research is needed to investigate effects of concurrent changes in primary care use and specialty care use, such as potential improvements in quality of care or patient outcomes. Future evaluations should also address whether the PCMH improves chronic illness management in primary care settings or reduces the incidence of complications treated in specialty settings.

We observed decreased likelihoods of visits to cardiology and consultative internal medicine, two specialties where GH patients are likely to receive specialty care relating to refractory or complicated hypertensive disease and associated medical comorbidities. Since provider referrals were required for consultative internal medicine visits, the reduction in hypertensive patients visiting this specialty must be attributable to changes in provider referral patterns. In other specialties, such as eye care and orthopedic surgery, the increased likelihood of year three visits may represent an attenuation of this PCMH redesign's impact over time.

This study has several limitations. One major limitation was our inability to extract data on visits to nephrologists, who frequently provide care to hypertensive patients with chronic kidney disease. Our specialty use data did not contain information on whether visits occurred following provider referral or patient self-referral, limiting our ability to comment on how the PCMH impacted provider referrals. The integrated delivery system under study differs from the majority of American care settings with regard to financing mechanisms, provider referral patterns (the majority of specialty use at GH occurs following primary care provider referral) and coordination between primary care providers and specialists. Although we were confident that included individuals had treated hypertension, our inclusion criteria excluded those with undiagnosed, untreated or potentially less complex hypertension. Results for included individuals may not be generalizable to populations with different health care conditions or different distributions of morbidity burden.

The study's design and analytic approach also have limitations. "The Great Recession" of 2007–2009[35] could have contributed to observed decreases in specialty use, though a review of monthly mean specialty visits during the 2 years preceding the system-wide PCMH redesign revealed no noteworthy changes following the starts of the economic contraction (December 2007) or the financial crisis (September 2008). Though we controlled for secular trends for calendar periods, we were unable to control for other temporal factors, such as potential changes in specialty use in the entire primary care population with cardiovascular diseases. It is possible that results were affected by endogeneity of morbidity measurement using ACG software; namely, that increased primary care use in the PCMH redesign led to an increase in ICD-9 diagnoses, which in turn could have increased RUB comorbidity estimates. We believe this scenario unlikely, because the low morbidity burden group experienced the greatest proportional increase in size over time (Fig. 1).

This study demonstrates the potential impact of comprehensive primary care on specialty use. Redesigning care to the PCMH may enable primary care teams to take on additional tasks within their expertise, leading to fewer specialty visits for low morbidity patients, and to a limited extent, for medium morbidity patients. Observed increases in specialty use for high morbidity patients highlight the need for effective co-management by primary care teams and specialists.[14] Findings suggest that new approaches to care coordination between primary care teams and specialists in the "medical neighborhood"[11] should prioritize high morbidity, clinically complex patients.

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REFERENCES

1. American Academy of Family Physicians, American Academy of Pediatrics, American College of Physicians, American Osteopathic Association. Joint principles of the patient-centered medical home. 2007; http://www.aafp.org/dam/AAFP/documents/practice_management/pcmh/initiatives/PCMHJoint.pdf. Accessed January 10, 2014.
2. **Berenson RA, Hammons T, Gans DN, et al.** A house is not a home: keeping patients at the center of practice redesign. Health Aff (Millwood). 2008;27(5):1219–1230.
3. **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):105–116.
4. **Williams JW, Jackson GL, Powers BJ, et al.** The Patient-Centered Medical Home. Closing the Quality Gap: Revisiting the State of the Science. Agency for Healthcare Research and Quality: Rockville, MD; 2012.
5. **Jackson GL, Powers BJ, Chatterjee R, et al.** The Patient-Centered Medical Home: A Systematic Review. Ann Int Med. 2013;158(3):169–178.
6. **Rittenhouse DR, Thom DH, Schmittdiel JA.** Developing a policy-relevant research agenda for the patient-centered medical home: a focus on outcomes. J Gen Intern Med. 2010;25(6):593–600.
7. **Rosenthal MB, Beckman HB, Forrest DD, Huang ES, Landon BE, Lewis S.** Will the patient-centered medical home improve efficiency and reduce costs of care? A measurement and research agenda. Med Care Res Rev. 2010;67(4):476–484.
8. **Hollingsworth JM, Saint S, Hayward RA, Rogers MA, Zhang L, Miller DC.** Specialty care and the patient-centered medical home. Med Care. 2011;49(1):4–9.
9. **Reid RJ, Fishman PA, Yu O, et al.** Patient-centered medical home demonstration: a prospective, quasi-experimental, before and after evaluation. Am J Manag Care. 2009;15(9):e71–e87.
10. American College of Physicians. The Patient-Centered Medical Home Neighbor: The Interface of the Patient-Centered Medical Home with Specialty/Subspecialty Practices. 2010; www.acponline.org/advocacy/where_we_stand/policy/pcmh_neighbors.pdf. Accessed January 10, 2014.
11. **Fisher ES.** Building a medical neighborhood for the medical home. N Engl J Med. 2008;359(12):1202–1205.
12. **Starfield B.** Point: the changing nature of disease: implications for health services. Med Care. 2011;49(11):971–972.
13. **Forrest CB, Reid RJ.** Prevalence of health problems and primary care physicians' specialty referral decisions. J Fam Pract. 2001;50(5):427–432.
14. **Forrest CB.** A typology of specialists' clinical roles. Arch Intern Med. 2009;169(11):1062–1068.
15. **Starfield B, Lemke KW, Bernhardt T, Foldes SS, Forrest CB, Weiner JP.** Comorbidity: implications for the importance of primary care in 'case' management. Ann Fam Med. 2003;1(1):8–14.
16. **Starfield B, Lemke KW, Herbert R, Pavlovich WD, Anderson G.** Comorbidity and the use of primary care and specialist care in the elderly. Ann Fam Med. 2005;3(3):215–222.
17. **Roos NP, Carriere KC, Friesen D.** Factors influencing the frequency of visits by hypertensive patients to primary care physicians in Winnipeg. CMAJ. 1998;159(7):777–783.
18. **Margolius D, Bodenheimer T.** Controlling hypertension requires a new primary care model. Am J Manag Care. 2010;16(9):648–650.
19. **Reid RJ, Johnson EA, Hsu C, et al.** Spreading a medical home redesign: effects on emergency department use and hospital admissions. Ann Fam Med. 2013;11(Suppl 1):S19–S26.
20. **Hsu C, Coleman K, Ross TR, et al.** Spreading a patient-centered medical home redesign: a case study. J Ambul Care Manag. 2012;35(2):99–108.
21. **Reid RJ, Coleman K, Johnson EA, et al.** The group health medical home at year two: cost savings, higher patient satisfaction, and less burnout for providers. Health Aff (Millwood). 2010;29(5):835–843.
22. **Liss DT, Fishman PA, Rutter CM, et al.** Outcomes among chronically ill adults in a medical home prototype. Am J Manag Care. 2013;19(10):e348–e358.
23. **Shadish WR, Cook TD, Campbell DT.** Experimental and Quasi-Experimental Designs for Generalized Causal Inference. Boston: Houghton Mifflin; 2002.
24. **Bullano MF, Kamat S, Willey VJ, Barlas S, Watson DJ, Brenneman SK.** Agreement between administrative claims and the medical record in identifying patients with a diagnosis of hypertension. Med Care. 2006;44(5):486–490.
25. **Sibai BM.** Diagnosis and management of chronic hypertension in pregnancy. Obstet Gynecol. 1991;78(3 Pt 1):451–461.
26. **Carrell D, Ralston J.** Messages, strands and threads: measuring use of electronic patient-provider messaging. AMIA Annu Symp Proc. 2005:913.
27. **Hardcastle JD, Chamberlain JO, Robinson MH, et al.** Randomised controlled trial of faecal-occult-blood screening for colorectal cancer. Lancet. 1996;348(9040):1472–1477.
28. The Johns Hopkins ACG System: Technical Reference Guide, Version 10.0. Baltimore, MD: Johns Hopkins University; 2011.
29. **Forrest CB, Nutting PA, Starfield B, von Schrader S.** Family physicians' referral decisions: results from the ASPN referral study. J Fam Pract. 2002;51(3):215–222.

30. **Ralston JD, Martin DP, Anderson ML, et al.** Group health cooperative's transformation toward patient-centered access. Med Care Res Rev. 2009;66(6):703–724.
31. **Gardner W, Mulvey EP, Shaw EC.** Regression analyses of counts and rates: Poisson, overdispersed Poisson, and negative binomial models. Psychol Bull. 1995;118(3):392–404.
32. **Zou G.** A modified poisson regression approach to prospective studies with binary data. Am J Epidemiol. 2004;159(7):702–706.
33. **Zou GY, Donner A.** Extension of the modified Poisson regression model to prospective studies with correlated binary data. Stat Methods Med Res. 2011.
34. **Diggle P, Heagerty P, Liang K, Zeger S.** Analysis of Longitudinal Data. 2nd ed. Norfolk, UK: Oxford University Press; 2002.
35. Rockford Register Star. Key dates of the Great Recession. 2012; http://www.rrstar.com/x417563916/Key-dates-of-the-Great-Recession. Accessed January 10, 2014.