ORIGINAL RESEARCH

Impact of Case Mix Severity on Quality Improvement in a Patient-centered Medical Home (PCMH) in the Maryland Multi-Payor Program

Niharika Khanna, MBBS, Fadia T. Shaya, PhD, MPH, Viktor V. Chirikov, MS, PhD, David Sharp, PhD, and Ben Steffen, MA

Background: We present data on quality of care (QC) improvement in 35 of 45 National Quality Forum metrics reported annually by 52 primary care practices recognized as patient-centered medical homes (PCMHs) that participated in the Maryland Multi-Payor Program from 2011 to 2013.

Methods: We assigned QC metrics to (1) chronic, (2) preventive, and (3) mental health care domains. The study used a panel data design with no control group. Using longitudinal fixed-effects regressions, we modeled QC and case mix severity in a PCMH.

Results: Overall, 35 of 45 quality metrics reported by 52 PCMHs demonstrated improvement over 3 years, and case mix severity did not affect the achievement of quality improvement. From 2011 to 2012, QC increased by 0.14 ($P < .01$) for chronic, 0.15 ($P < .01$) for preventive, and 0.34 ($P < .01$) for mental health care domains; from 2012 to 2013 these domains increased by 0.03 ($P = .06$), 0.04 ($P = .05$), and 0.07 ($P = .12$), respectively. In univariate analyses, lower National Commission on Quality Assurance PCMH level was associated with higher QC for the mental health care domain, whereas case mix severity did not correlate with QC. In multivariate analyses, higher QC correlated with larger practices, greater proportion of older patients, and readmission visits. Rural practices had higher proportions of Medicaid patients, lower QC, and higher QC improvement in interaction analyses with time.

Conclusions: The gains in QC in the chronic disease domain, the preventive care domain, and, most significantly, the mental health care domain were observed over time regardless of patient case mix severity. QC improvement was generally not modified by practice characteristics, except for rurality. (J Am Board Fam Med 2016;29:116–125.)

Keywords: Medical Home, Patient-centered Care, Practice-based Research, Quality of Health Care

Patient-centered medical homes are an important building block for health care reform and a mechanism for achieving quality improvement.[1,2] Patient-centered interactions with optimal utilization of health information technology and primary care teams have potential for enhancing chronic disease management and the delivery of preventive care.[3–5] Patient-centered care management has been demonstrated to enhance the quality of care (QC) delivered and chronic disease management.[6,7] Patient-centered medical home (PCMH) capacity

enhancements lead to potential impacts on the behavioral health care of patients overall and, in particular, on patients with high utilization and with a high probability for the coexistence of anxiety and depression.[8]

Quality improvements are critical to advanced primary care models within PCMHs and are frequently linked to shared savings and lowering the total costs of care.[9] Impact on quality may vary by practice characteristics, including a practice's ability to change, the population served, and the disease burden among the population served.[10] For example, research on multimorbidity has identified the patient case mix as one of the measures for testing their validity in relation to expected patient association characteristics and outcomes.[11,12] There are, however, gaps in the literature on whether quality improvement in a PCMH varies by patient and practice characteristics, as well as which characteristics most strongly influence quality. To explore the link between patient and practice characteristics and QC delivered, this study was conducted in the 52 PCMHs (14 adult, 32 mixed adult and pediatric, and 6 pediatric practices) that are located in community settings and that volunteered to participate in the Maryland Multi-Payor Program (MMPP).[13,14]

Each PCMH is recognized by the National Commission on Quality Assurance (NCQA), has established primary care teams and care management procedures, and the majority are linked to the state-designated health information exchange to receive data on patient utilization of hospital and emergency departments. All PCMHs annually self-report quality metrics to the MMPP through a Web-based portal, and they benefit from linked shared savings based on the achievement of quality thresholds.[15] Practices also receive learning support provided by the Maryland Learning Collaborative to create a forum for collaborating, sharing evidence-based practices, supporting quality improvement, disseminating the state's advanced primary care model, and assisting data extraction by conducting electronic health record user groups to optimize NQF metric extraction using preset specifications.[13,14,16] In addition, quality improvement and health care utilization formed the basis for each practice's eligibility for shared savings from commercial and public insurance carriers.[15] This article presents observations in quality improvement in the 52 primary care practices that are recognized as

PCMHs, and conducts an exploratory analysis of patient and practice characteristics that determine quality improvement.

Methods

The study uses a panel data design with no control group. Data on 45 quality metrics were available for 52 practices for the years 2011 (baseline), 2012, and 2013. We categorized the quality metrics into 3 domains: (1) chronic care domain (metrics related to asthma assessment and appropriate use of medications, blood pressure and heart disease measurement and management, diabetes control); (2) preventive care domain (in children and adolescents: body mass index assessment, nutrition counseling, physical activity counseling, and vaccinations; in adults: tobacco use assessment and cessation intervention, vaccinations, colorectal cancer screening, and weight screening); and (3) mental health care domain (2 metrics related to antidepressant use among adults) (Table 1). Not all 52 practices reported measurement of each individual quality care metric because metrics were applicable to different types of patient populations served by primary care practices (pediatric, adult, or mixed). Quality metrics reported by practices annually over a period of 3 years were analyzed for each of the chronic disease, preventive, and mental health care domains, as well as by each individual metric.

All practice characteristics were measured in the baseline year 2011 and included practice type (adult, pediatric, or mixed) and size, NCQA 2008/2011 PCMH level, level of shared savings eligibility, location in a rural versus urban region, use of telemedicine, participation in the state's health information exchange, and the patient distribution at each practice (by age, sex, and source of insurance). In addition, we examined the amount of fixed transformation payment (determined by a variety of factors, such as size of practice, number of patients, and NCQA level), as well as health care utilization, calculated per 1000 patients, for inpatient length of stay, emergency visits, and 30-day readmission visits.

The case-mix severity of each practice population was calculated using the well-established Johns Hopkins Adjusted Clinical Groups (ACG) Case-Mix System.[11,12,17] Using available 2010 administrative claims data for primary and specialty ambulatory care, inpatient care, and pharmacy for each

Table 1. Description of National Quality Forum Quality Metric Measures Reported By Patient Centered Medical Homes Practices (n = 52)*

Domain Designation	Measure Number	Measure Description[†]	Type of Practice Reporting
Chronic disease	NQF 1	Percentage of patients aged 5–40 years with asthma seen for at least 2 office visits and who were evaluated within 12 months for the frequency of asthma symptoms	Adult/pediatric/ mixed
	NQF 13	Percentage of visits for patients >18 years old with hypertension seen for at least 2 office visits, with BP recorded	Adult/mixed
	NQF 18[‡]	Percentage of patients 18–85 years of age who had a diagnosis of hypertension and whose BP was adequately controlled during the years	Adult/mixed
	NQF 36	Percentage of patients who were identified as having persistent asthma, were appropriately prescribed medication, and of the ages: •N1D1: 4–10 years •N2D2: 11–49 years •N3D3: 4–49 years	Adult/pediatric/ mixed
	NQF 47	Percentage of patients aged 5–40 years with mild, moderate, or severe persistent asthma who were prescribed inhaled corticosteroid or an acceptable alternative	Adult/pediatric/ mixed
	NQF 59[‡]	Percentage of patients 18–75 years of age with diabetes (type 1 or type 2) who had HbA_{1c} >9.0%	Adult/mixed
	NQF 61	Percentage of patients 18–75 years of age with diabetes (type 1 or type 2) who had BP <140/90 mm Hg	Adult/mixed
	NQF 67	Percentage of patients with coronary artery disease, ≥18 years old, who were prescribed an oral antiplatelet agent	Adult/mixed
	NQF 75	Percentage of patients with ischemic vascular disease, ≥18 years old, who: •N1D1: were tested for complete lipid profile •N2D1: have LDL <100 mg/dL	Adult/mixed
	NQF 81	Percentage of patients with heart failure, ≥18 years old, and prescribed an ACE inhibitor or ARB therapy	Adult/mixed
	NQF 575[‡]	Percentage of patients 18–75 years of age with diabetes (type 1 or type 2) who had HbA_{1c} <8.0%	Adult/mixed
Preventive care	NQF 24	Percentage of patients aged 2–16 years of age who had outpatient visit with a PCP or OB/GYN and had evidence of: •N1D1: BMI percentile documentation •N2D1: nutrition counseling •N3D1: physical activity counseling •N1D2: BMI percentile documentation (age 2–10 years) •N2D2: nutrition counseling (age 2–10 years) •N3D2: physical activity counseling (age 2–10 years) •N1D3: BMI percentile documentation (age 11–16 years) •N2D3: nutrition counseling (age 11–16 years) •N3D3: physical activity counseling (age 11–16 years)	Pediatric/mixed
	NQF 0028a[‡]	The percentage of patients, who are ≥18 years of age, have been seen for at least 2 office visits, and who were queried about tobacco use within 24 months	Adult/mixed
	NQF 0028b[‡]	The percentage of patients, who are ≥18 years of age, have been seen for at least 2 office visits, and who received cessation intervention	Adult/mixed
	NQF 34	Percentage of adults 50–75 years of age who had appropriate screening for colorectal cancer	Adult/mixed
	NQF 38	The percentage of children 2 years of age who had the following vaccines and/or their combinations by their 2nd birthday: •N1D1: diphtheria, tetanus, acellular pertussis (4× DTaP) •N2D1: polio (IPV) •N3D1: measles, mumps, rubella (MMR) •N4D1: H influenza type B (2× HIB) •N5D1: hepatitis B (3× HBV) •N6D1: chicken pox (VZV) •N7D1: pneumonococcal conjugate (4× PCV) •N8D1: hepatitis A (2× Hep A) •N9D1: rotavirus vaccines (2/3× RV) •N10D1: influenza vaccines (2) •N11D1: combination 1 (4× DTaP, 3× IPV, 1× MMR, 1× VZV, 3× HBV) •N12D1: combination 2 (4× DTaP, 3× IPV, 1× MMR, 1× VZV, 3× HBV, 4× PCV)	Pediatric/mixed

Continued

Table 1. Continued

Domain Designation	Measure Number	Measure Description[†]	Type of Practice Reporting
	NQF 41	Percentage of patients aged ≥50 years old who received influenza immunization during the flu season (September through February).	Adult/mixed
	NQF 43	Percentage of patients ≥65 years old who have ever received a pneumococcal vaccine	Adult/mixed
	NQF 421	Percentage of patients aged 18 to ≥65 years with a calculated BMI in past 6 months or during the current visit documented AND, if the most recent BMI is outside parameters, a follow-up plan is documented	Adult/mixed
	NQF 2	Percentage of children 2–18 years of age who were diagnosed with pharyngitis, dispensed an antibiotic, and received a group A streptococcus (strep) test for the episode.	Pediatric/mixed
Mental health	NQF 105	Percentage of patients ≥18 years old who were diagnosed with a new episode of major depression and dispensed antidepressant medication for: •N1D1: ≥84 days after diagnosis •N2D1: ≥180 days after diagnosis	Adult/mixed

*The 52 practices comprised 6 pediatric, 14 adult, and 32 mixed practices.

[†]In the descriptions, the N represents the numerator and D, the denominator. In these measures the denominator typically consists of patient characteristics such as age and, occasionally, a diagnosed disease condition, whereas the numerator indicates access to a health care service (eg, screening, counseling, prescription of medication) or treatment success.

[‡]This National Quality Forum (NQF) quality metric was measured by practices under the Million Hearts initiative.

ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; BMI, body mass index; BP, blood pressure; LDL, low-density lipoprotein; OB/GYN, obstetrician/gynecologist; PCP, primary care physician.

patient assigned to a practice, 1 of approximately 90 ACGs was assigned to each individual, reflecting morbidity burden and expected resource use. These mutually exclusive categories then were combined into 1 of 5 broad "resource use bands" (RUBs), which ranged from "healthy" (1) to "very high risk" (5).[17] A practice case-mix score was calculated based on the distribution of patients assigned to each PCMH within each of these 5 ACG-based RUB categories. Thus the lowest possible score was 1 and the highest 5.

Statistical Analysis

We broke down the distribution of continuous practice characteristics into categorical variables approximating the empirical quartile or half points of the distribution. For example, practices were categorized into low and high case-mix severity practices according to whether their ACG case-mix value fell below or above the median ACG-based RUB case-mix score determined by the morbidity mix of the individual patients assigned to the practice.

In descriptive analyses the overall average change from 2011 to 2013 was calculated and tested for statistical significance using Student t test. When examining changes by individual quality care metrics, we additionally compared quality metric scores

by the achievement threshold criterion, defined as the 25th percentile for performance among the MMPP practices. In univariate analyses, using longitudinal fixed-effects regressions controlling for the measurement year (Proc Mixed procedure in SAS version 9.2; SAS Institute, Cary, NC), we modeled the association between practice characteristics and the annual calculated score for each of the 3 quality health care domains (Online Appendix Table 1).

Selecting only those variables that were significant at $P \leq .20$, we conducted multivariate, longitudinal, fixed-effects regression for each quality health care domain and determined the best model fit using the Akaike information criterion. Using interaction terms with the follow-up measurement years (2012 to 2013), we examined whether the change in quality score from 2011 was modified by practice characteristics. Given the small sample size of the practices included, we considered findings with $P \leq .05$ to be statistically significant, whereas $.05 < P \leq .10$ represented some evidence of an association.

Results

More than three quarters of practices were deemed NCQA practice level I in 2011. By 2012, each practice was recognized as a PCMH: 15 practices

Table 2. Maryland Multi-Payor Patient Centered Medical Home Program Practice Characteristics, 2011 (n = 52)

	Practices	
	No.	%
Practice type		
Adult	14	26.92
Mixed	32	61.54
Pediatric	6	11.54
Case mix		
High	32	61.54
Low	20	38.46
NCQA practice level		
Deemed level I	43	82.69
Level III	9	17.31
Shared savings eligibility		
30% share	10	19.23
40% share	22	42.31
50% share	20	38.46
Rural (federal designation)		
No	48	92.31
Yes	4	7.69
Telemedicine (rural)		
No	32	61.54
Yes	20	38.46
Health information exchange		
No	9	17.31
Yes	43	82.69
Practice size		
1 to 5 providers	23	44.23
6 to 10 providers	22	42.31
11 or more providers	7	13.46
Patient age, years (mean)		
0–18		25.90
19–49		43.09
≥50		33.59
Medicaid patients (mean)		27.65
Male patients (mean)		41.29
Fixed transformation payment (mean)	4.70	
Inpatient length of stay/1000 (median)	225.5	
Emergency visits/1000 (median)	220.0	
Readmission visits (30 day)/1000 (median)	3.8	

NCQA, National Committee for Quality Assurance.

were NCQA level 2 and 37 practices were NCQA level 3. About 8% of practices were rural, 83% participated in the state's health information exchange, and 13.5% were large practices with ≥11 providers each (Table 2). The practices' average ACG-based RUB case-mix score ranged from 1.14 to 2.96 for the practices with a "low" case mix, and from 2.97 to 3.83 for those with a "high" case mix.

The average proportion of patients on Medicaid (vs commercial insurance) was 27.7%, which correlated with a higher proportion of patients ≤18 years of age in the practice. Based on quality improvement, reduction of utilization and total costs of care, one fifth of practices were eligible for 30% of shared savings, with the remaining proportion of practices equally distributed between 40% and 50% shared savings eligibility in 2011.

We observed significant increases in the reported QC metrics for all 3 QC domains (Figure 1). For the chronic care domain, the average NQF quality metrics score increased from 0.417 to 0.568 for practices with a high case mix ($\delta = 0.150$; $P = .01$) and from 0.401 to 0.596 for practices with a low case mix ($\delta = 0.195$; $P = .01$). Similarly, for the preventive care domain, practices with high and low case mixes exhibited an increase from 0.330 to 0.540 ($\delta = 0.210$; $P = .01$) and 0.386 to 0.553 ($\delta = 0.167$; $P = .02$), respectively. Positive overall change was also observed with respect to the mental health care domain in practices with a high case mix (from 0.268 to 0.698; $\delta = 0.429$; $P < .01$) and a low case mix (from 0.271 to 0.649; $\delta = 0.377$; $P = .01$). Please refer to Online Appendix and Appendix Figures 1 through 5 for a discussion of results regarding change in quality by individual NQF metrics.

In univariate regression analyses controlling for measurement year (Table 3), lower levels of shared savings eligibility (for the chronic care domain), rural practices (for the chronic care and preventive care domains), a medium to high number of readmission visits (for the chronic care domain), practices of small size (for the preventive care domain), practices with a medium to high proportion of patients on Medicaid and with a high fixed transformation payment (for the mental health care domain) were associated with average lower QC scores. Higher QC scores correlated with a high proportion of patients 50 to 65 years of age (for the chronic care and mental health care domains), a high number of readmission visits (for the preventive care domain), and NCQA PCMH practice level I (for the mental health care domain). Burden of illness as measured by the dichotomous (high/low) case-mix designation was not associated with differential QC based on domains.

In multivariate analyses controlling for various practice characteristics (Table 4), the reported quality score increased from 2011 to 2012 by 0.14

Figure 1. Average National Quality Forum quality care metrics (QM) scores reported over the period 2011 to 2013 for the chronic care (left), preventive care (middle), and mental health care domains (right), stratified by practices with high and low case mix. *P* values designate statistical significance of the average total change from 2011 to 2013.
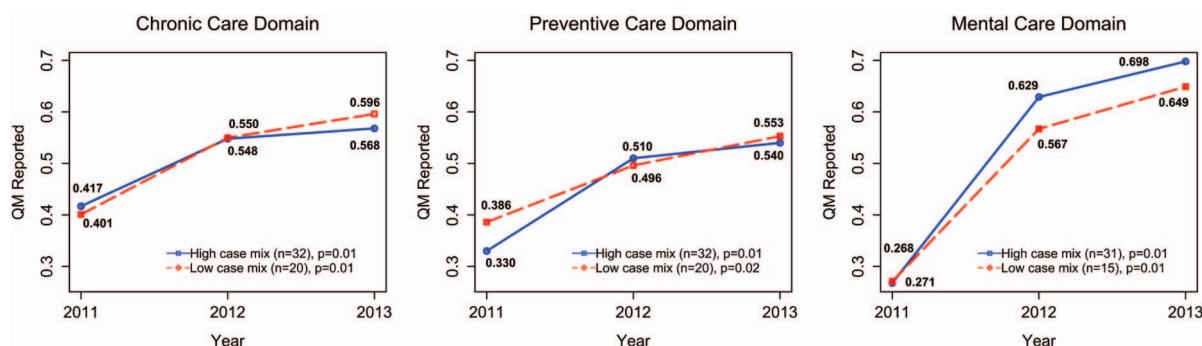
(*P* < .01), 0.15 (*P* < .01), and 0.34 (*P* < .01) for the chronic care, preventive care, and mental health care domains, respectively. However, to a smaller extent, the quality score improved even more from 2012 to 2013 by 0.03 (*P* = .06), 0.04 (*P* = .05), and 0.07 (*P* = .12) for the chronic care, preventive care, and mental health care domains, respectively. A higher proportion of older patients was associated with higher QC scores for the chronic care and mental health care domains, whereas larger practices correlated with a trend for higher QC scores in the preventive care domain. Interestingly, practices with a higher proportion of readmission visits were associated with a lower reported quality for the chronic care domain but higher quality for the preventive care domain.

In an analysis including interaction terms with time, despite having a 0.16 lower quality score in the baseline year (2011) than urban practices (for the chronic care domain), rural practices trended toward an average of 0.05 (*P* = .08) higher annual quality increase over 2011 to 2013 for the chronic care domain. Interaction terms between time and rurality were not significant in analyses for the preventive care domain (0.06; *P* = .28) and mental health care domain (0.04; *P* = .35). We did not detect differential quality improvement with respect to other practice characteristics.

Discussion

In this 3-year study of 52 PCMH sites, 35 of 45 quality metrics reported by the 52 PCMHs demonstrated improvement. Importantly, case-mix severity did not affect the achievement of quality improvement. The gains in quality occurred in the chronic disease domain, the preventive care domain, and, most significantly, in the mental health care domain.

There is limited literature on the impact of patient population on quality gains. Quality improvement in a PCMH includes enhanced management of diabetes, heart disease, and other chronic and mental diseases, which are relevant to care transitions and prevention of readmissions.[7,8] Enhanced prevention of disease is expected to affect patients downstream by lowering the severity of chronic disease and reducing utilization. Our report is consistent with recent reports from primary care practices transformed to PCMHs, which report gains in access, quality, and chronic disease metrics.[18,19] Our results also are consistent with small primary care practices that report gains in efficiency of the practice in addition to quality gains.[20] Other published reports have presented equivocal data on quality gains and cost savings.[10]

Limitations
One of the limitations noted was the small number of participating practices and the notable lack of a control group. Although a control cohort was identified by the MMPP using propensity matching to compare overall utilization, there was no collection of quality metrics by control practices. Thus, this article does not include an analysis using the same control practices. This is consistent with reports from other state-level programs where the use of control practices was used in various formats but not consistently across each domain.[21,22] Another limita-

Table 3. Univariate Analysis of Effect of Practice Characteristics on Reported National Quality Forum Metrics Scores, Controlling for Measurement Year

Characteristics	Chronic Care Domain (n = 52)		Preventive Care Domain (n = 52)		Mental Health Care Domain (n = 46)	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Case mix						
High (ACG ≥2.5)	−0.007	.84	−0.007	.83	0.039	.61
Low (ACG <2.5)	Reference		Reference		Reference	
Practice type						
Pediatric	0.10	.16	0.07	.31	−0.07	.35
Mixed	−0.05	.19	0.03	.52	—	
Adult	Reference		Reference		Reference	
NCQA practice level						
Deemed level I	0.03	.46	−0.06	.15	**0.21**	**.03**
Level III	Reference		Reference		Reference	
Shared savings eligibility						
30% share	**−0.16**	**<.0001**	−0.01	.74	−0.09	.10
40% share	**−0.12**	**.001**	−0.03	.39	−0.08	.33
50% share	Reference		Reference		Reference	
Rural (federal designation)						
Yes	**−0.05**	**.06**	**−0.10**	**.02**	−0.07	.31
No	Reference		Reference		Reference	
Rural (use of telemedicine)						
Yes	0.04	.26	−0.02	.62	0.08	.22
No	Reference		Reference		Reference	
Health information exchange						
Yes	0.03	.49	0.02	.70	0.09	.42
No	Reference		Reference		Reference	
Practice size (no. providers)						
1–5	0.00	.98	**−0.14**	**.02**	−0.02	.85
6–10	0.01	.82	−0.06	.30	0.01	.94
≥11	Reference		Reference		Reference	
Age ≥50 (mean %)						
High (top quartile: 0.444< and ≤0.722)	**0.08**	**.06**	−0.01	.86	**0.20**	**.04**
Medium (intermediate quartiles: 0.238< and ≤0.444)	0.00	.97	−0.02	.69	0.08	.41
Low (bottom quartile: ≤0.238)	Reference		Reference		Reference	
Medicaid patients (mean %)						
High (top quartile: 0.422< and ≤0.938)	−0.02	.70	0.03	.63	**−0.18**	**.08**
Medium (intermediate quartiles: 0.08< and ≤0.422)	−0.06	.16	−0.03	.51	**−0.17**	**.02**
Low (bottom quartile: ≤0.08)	Reference		Reference		Reference	
Male patients (mean %)						
High (top quartile: 0.470< and ≤0.586)	0.04	.36	0.04	.37	−0.04	.69
Medium (intermediate quartiles: 0.3674< and ≤0.470)	0.02	.50	0.01	.80	0.00	.95
Low (bottom quartile: ≤0.3674)	Reference		Reference		Reference	
Fixed transformation payment (2011)						
High (>4.68)	−0.03	.46	0.06	.15	**−0.21**	**.03**
Low (≤4.68)	Reference		Reference		Reference	
Inpatient length of stay (2011)						
High (top quartile: 280< and ≤622 per 1000)	−0.05	.23	0.02	.62	0.00	.97
Medium (intermediate quartiles: 148< and ≤280 per 1000)	−0.06	.13	−0.03	.40	0.09	.14
Low (bottom quartile: ≤148 per 1000)	Reference		Reference		Reference	

Continued

Table 3. Continued

Characteristics	Chronic Care Domain (n = 52)		Preventive Care Domain (n = 52)		Mental Health Care Domain (n = 46)	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Emergency department visits (2011)						
High (top quartile: 302.5< and ≤702)	0.06	.17	−0.003	.95	0.09	.29
Medium (intermediate quartiles: 190< and ≤302.5 per 1000)	0.03	.40	−0.01	.75	0.00	.97
Low (bottom quartile: ≤190 per 1000)	Reference		Reference		Reference	
Readmission visits (2011)						
High (top quartile: ≤2.56 per 1000)	−0.06	.12	**0.05**	**.10**	0.05	.60
Medium (Intermediate quartiles: 2.56< and ≤7.321 per 1000)	**−0.06**	**.07**	−0.01	.85	0.00	.98
Low (bottom quartile: 7.321< and ≤20.4 per 1000)	Reference		Reference		Reference	

ACG, adjusted clinical group; NCQA, National Committee for Quality Assurance. Bold values denote statistically significant values, at the 0.05 level.

tion is the limited observation period, from 2011 to 2013, which may include the period when practices were transforming to an NCQA-recognized PCMH and actual quality gains may be just starting to manifest. All NCQA-level achievement observations in the tables are from 2011/2012 in year 1, and ACG observations are also from 2011 data. Time-varying change in case-mix severity is not reflected in these observations. Since quality gains were used in calculation of shared savings for practices, it is possible that

Table 4. Multivariate Fixed Effects Analysis of Determinants of Reported National Quality Forum Scores By Maryland Multi-Payor Patient Centered Medical Home Program Practices

	Chronic Care Domain (n = 52)		Preventive Care Domain (n = 52)		Mental Health Care Domain (n = 46)	
	Change	P Value	Change	P Value	Change	P Value
Change from 2011–2012	**0.14**	**<.0001**	**0.15**	**<.0001**	**0.34**	**<.0001**
Change from 2012–2013	**0.03**	**.06**	**0.04**	**.05**	**0.07**	**.12**
Practice type						
Pediatric	**0.12**	**.04**	0.08	.13	—	—
Mixed	0.03	.22	0.04	.33	0.11	.22
Adult	Reference		Reference		Reference	
Shared savings eligibility						
30% or 40% (vs 50%)	**−0.11**	**.01**	−0.06	.15	−0.04	.48
Patients aged ≥50 years (mean %)						
High (vs medium/low)	**0.07**	**.02**	—	—	**0.19**	**.04**
Practice size						
≥6 providers (vs <6)	—	—	**0.09**	**.05**	—	—
Rural (federal designation)	**−0.11**	**.03**	−0.07	.09	−0.09	.26
Medicaid patients (2011) (%)						
High/medium (vs low)	—	—	—	—	**−0.14**	**.05**
Readmission visits per 1000 (2011)						
High (vs. medium/low)	−0.03	.24	**0.06**	**.03**	—	—

"High" designates the top quartile of variable distribution; "medium" designates the interquartile range (Q25–Q75) of the variable distribution; and "low" designates the bottom quartile of variable distribution. Bold values denote statistically significant values, at the 0.05 level.
—, Variable is not included in the model.

Case Mix Severity Impact on Quality Improvement in a PCMH

this may have motivated practices to consistently report quality data and for improvements in practice workflows. Although practice coaching was provided in addition to electronic health record user groups, the quality data were self-reported by practices, with limited support.

Quantification of case-mix severity of PCMH populations in this study used the ACG methodology to correlate to quality gains. Although the ACG system has been used in predictive modeling for future morbidity and health care utilization, the same ACG procedures provided the robust basis for the correlation of patient characteristics with PCMH quality improvement.

Practices that were measured for quality in this study were participating in the MMPP, where each practice had transformed to a PCMH and had been recognized by the NCQA. All practices participated in the Maryland Learning Collaborative, where local best practices were highlighted and each practice received limited practice coaching. In addition, practices had opportunities to teleconference with experts, had opportunities to learn evidence-based guidelines via webinars, and were recipients of disseminated Maryland health care policy. Practices did become eligible for shared savings if quality metrics and overall utilization and costs demonstrated containment. Thus practices may have been dually motivated to enhance quality through a reinvigorated focus on patient centered care and the opportunity for shared savings.[15]

Conclusion
Our study suggests that quality improvement consistently occurs in a PCMH with team-based care, care coordination, enhanced access, and efficiency, regardless of the patient case-mix severity burden. Patient factors summarized in case-mix severity do not affect the achievement of quality improvement in the majority of quality metrics for a PCMH. Thus becoming a PCMH is a robust systematic change in primary care practices to achieve higher QC delivery.

References
1. Paustian ML, Alexander JA, El Reda DK, Wise CG, Green LA, Fetters MD. Partial and incremental PCMH practice transformation: implications for quality and costs. Health Serv Res 2014; 49:52–74.
2. Wagner EH, Coleman K, Reid RJ, Phillips K, Abrams MK, Sugarman JR. The changes involved in patient-centered medical home transformation. Prim Care 2012;39:241–59.
3. Wang JJ, Winther CH, Cha J, et al. Patient-centered medical home and quality measurement in small practices. Am J Manag Care 2014;20:481–9.
4. Liss DT, Fishman PA, Rutter CM, et al. Outcomes among chronically ill adults in a medical home prototype. Am J Manag Care 2013;19:e348–58.
5. Pandhi N, DeVoe JE, Schumacher JR, et al. Preventive service gains from first contact access in the primary care home. J Am Board Fam Med 2011;24: 351–9.
6. Jackson GL, Powers BJ, Chatterjee R, et al. Improving patient care. The patient centered medical home. A systematic review. Ann Intern Med 2013; 158:169–78.
7. Page TF, Amofah SA, McCAnn S, et al. Care management medical home center model: preliminary results of a patient-centered approach to improving care quality for diabetic patients. Health Promot Pract 2015;16:609–16.
8. Kessler R, Miller BF, Kelly M, et al. Mental health, substance abuse, and health behavior services in patient-centered medical homes. J Am Board Fam Med 2014;27:637–44.
9. Stockbridge EL, Philpot LM, Pagan JA. Patient-centered medical home features and expenditures by medicare beneficiaries. Am J Manag Care 2014;20: 379–85.
10. 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;18:105–16.

11. Huntley AL, Johnson R, Purdy S, Valderas JM, Salisbury C. Measures of multimorbidity and morbidity burden for use in primary care and community settings: a systematic review and guide. Ann Fam Med 2012;10:134–41.

12. The Johns Hopkins University Bloomberg School of Public Health. The Johns Hopkins ACG System: Technical Reference Guide, version 9.0. Baltimore: Johns Hopkins University; 2009. Available from: http://www.acg.jhsph.org. Accessed February 12, 2015.

13. Khanna N, Shaya F, Chirikov V, Steffen B, Sharp D. Dissemination and adoption of the advanced primary care model in the Maryland multi-payer patient centered medical home program. J Health Care Poor Underserved 2014;25(1 Suppl):122–38.

14. Khanna N. Community tailored partnerships that work: implementing new models of primary care in the state of Maryland. Maryland Med 2014;14:15–7.

15. Bailit M, Hughes C, Burns M, et al. Shared-savings payment arrangements in health care: six case studies. New York: Commonwealth Fund; 2012.

16. National Quality Forum [homepage]. Available from: http://www.qualityforum.org/Home.aspx. Accessed July 15, 2015.

17. Weiner JP, Starfield BH, Steinwachs DM, Mumford LM. Development and application of a population-oriented measure of ambulatory care case-mix. Med Care 1991;29:452–72.

18. Brilleman SL, Gravelle H, Hollinghurst S, Purdy S, Salisbury C, Windmeijer F. Keep it simple? Predicting primary health care costs with clinical morbidity measures. J Health Econ 2014;35:109–22.

19. Christensen EW, Dorrance KA, Ramchandani S, et al. Impact of a patient-centered medical home on access, quality, and cost. Mil Med 2013;178: 135–41.

20. Fifield J, Forrest DD, Burleson JA, Martin-Peele M, Gillespie W. Quality and efficiency in small practices transitioning to patient centered medical homes: a randomized trial. J Gen Intern Med 2013;28:778–86.

21. Fontaine P, Whitebird R, Solberg LI, Tillema J, Smithson A, Crabtree BF. Minnesota's early experience with medical home implementation: viewpoints from the front lines. J Gen Intern Med 2015;30:899–906.

22. Rissi JJ, Gelmon S, Saulino E, Merrithew N, Baker R, Hatcher P. Building the foundation for health system transformation: Oregon's patient-centered primary care home program. J Public Health Manag Pract 2015;21:34–41.

Appendix

In the chronic care domain, 8 of 14 metrics exhibited statistically significant increases in reported quality from 2011 to 2013 (Appendix Figure 1). Most metrics met the respective quality achievement threshold by the last year of measurement, with the exception of NQF67 (oral antiplatelet therapy for adult patients with coronary artery disease) and NQF81 (angiotensin-converting enzyme inhibitor or angiotensin receptor blocker therapy for adult patients with heart failure), for which we observed nonsignificant change over time. Furthermore, 8 quality metrics that had started below the achievement thresholds in the baseline year achieved or surpassed the threshold by year 2013 (blood pressure measurement, ischemic vascular disease patients with complete lipid profile and low-density lipoprotein cholesterol <100 mg/dL, and all metrics related to asthma assessment and medications).

In the metrics belonging to the preventive care domain and related to body mass index assessment and nutrition and physical counseling for children and adolescents (Appendix Figure 2), we observed significant increases for all 9 metrics among practices with a high case mix (all 9 metrics above threshold by 2013) and for 4 of 9 metrics among practices with a low case mix (but again, all 9 were above the threshold or within an acceptable range by 2013).

For pediatric vaccination metrics belonging to the preventive care domain (Appendix Figure 3),

Appendix Table 1. Maryland Multi-Payor Patient Centered Medical Home Program Practice Characteristics By High and Low Case Mix

	High Case Mix (n = 32)		Low Case Mix (n = 20)		
	No.	%	No.	%	P Value
Practice type					
Adult	12	37.5	2	10.0	
Mixed	19	59.4	13	65.0	.01
Pediatric	1	3.1	5	25.0	
Rural (federal designation)					
No	30	93.8	18	90.0	.63
Yes	2	6.3	2	10.0	
Use of telemedicine					
No	19	59.4	13	65.0	.77
Yes	13	40.6	7	35.0	
NCQA Practice level					
Deemed level I	26	81.3	17	85.0	.73
Level III	6	18.8	3	15.0	
Shared savings eligibility					
30% share	6	18.8	4	20.0	.57
40% share	12	37.6	10	50.0	
50% share	14	43.8	6	30.0	
Health information exchange					
No	4	12.5	5	25.0	.28
Yes	28	87.5	15	75.0	
Practice size (no. providers)					
1–5	15	46.9	8	40.0	.65
6–10	12	37.5	10	50.0	
≥11	5	15.6	2	10.0	
Medicaid patients (mean %)		13.0		24.6	.04
Mean age, years (%)					
0–18		17.1		40.0	.01
19–49		45.7		39.0	.20
≥50		37.2		26.3	.02

NCQA, National Committee for Quality Assurance.

Appendix Figure 1. Chronic care domain: average National Quality Forum (NQF) quality metrics (QM) scores reported for 2011 to 2013, stratified by practices with high and low case mixes. P values designate statistical significance of the mean total change from 2011 to 2013.
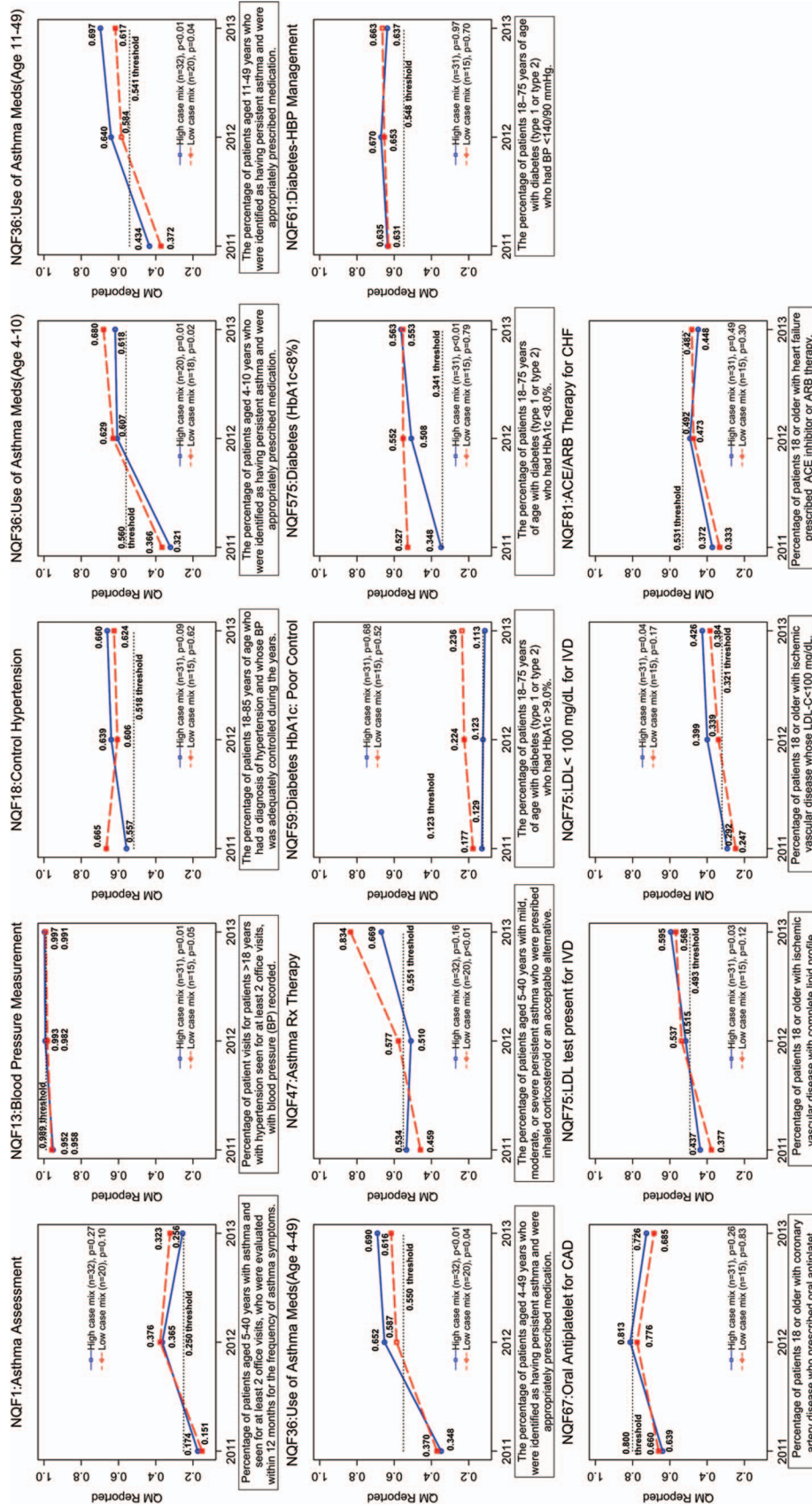
Appendix Figure 2. Preventive care domain (body mass index assessment, physical activity counseling, and nutrition counseling for children): average National Quality Forum (NQF) quality metrics (QM) scores reported over the years 2011 to 2013, stratified by practices with high and low case mixes. *P* values designate statistical significance of the average total change from 2011 to 2013.
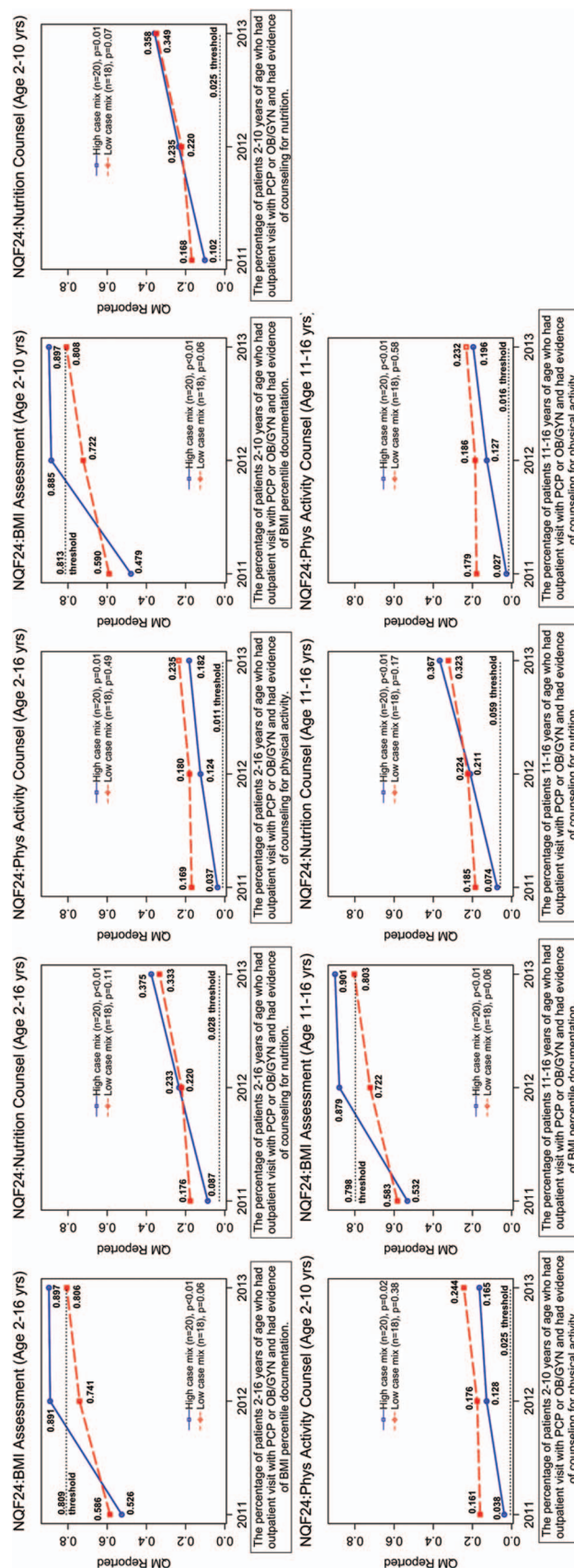
Appendix Figure 3. Preventive care domain (children's vaccinations): average National Quality Forum (NQF) quality metrics (QM) scores reported over the years 2011 to 2013, stratified by practices with high and low case mixes. *P* values designate statistical significance of the average total change from 2011 to 2013.
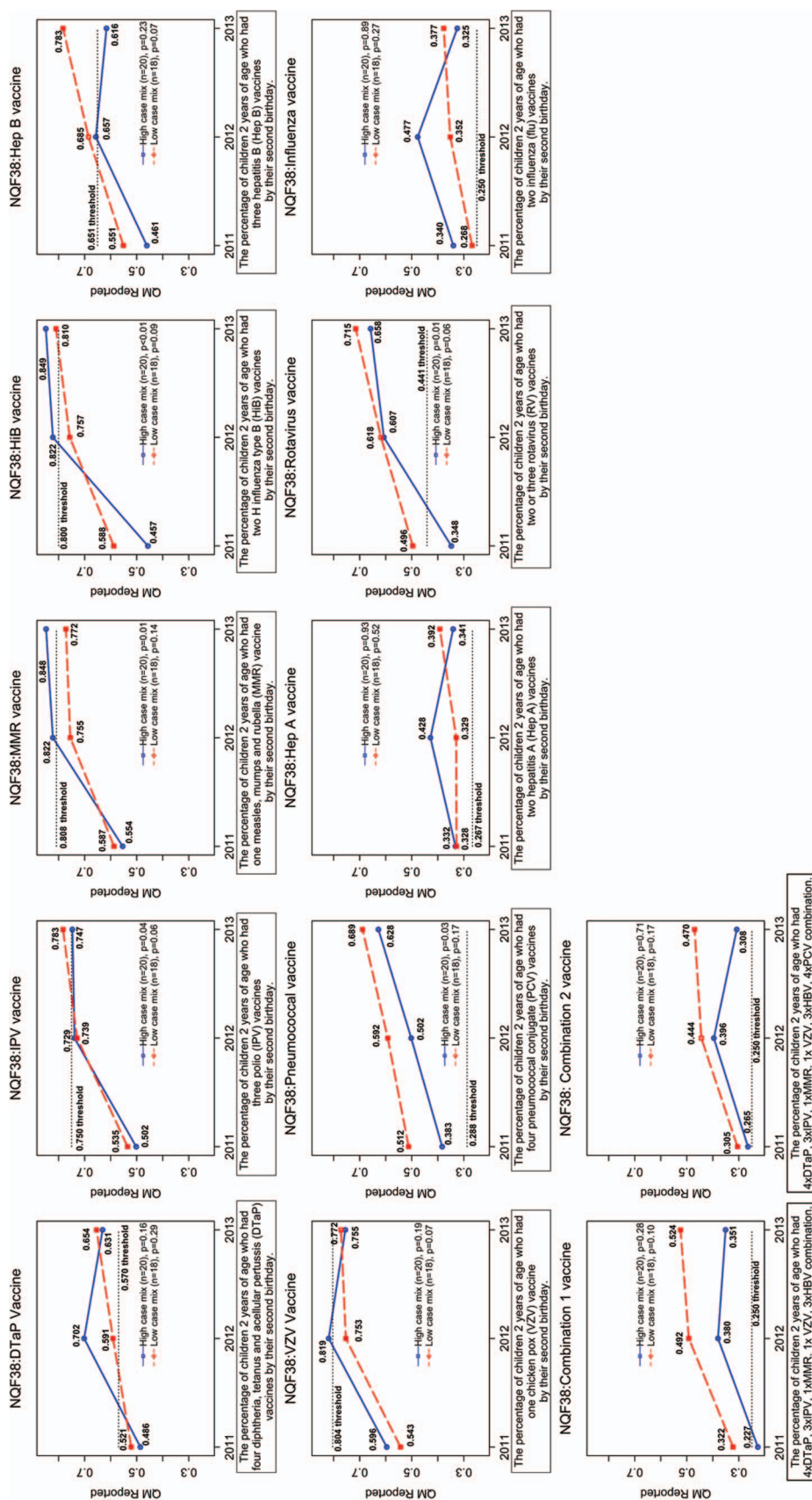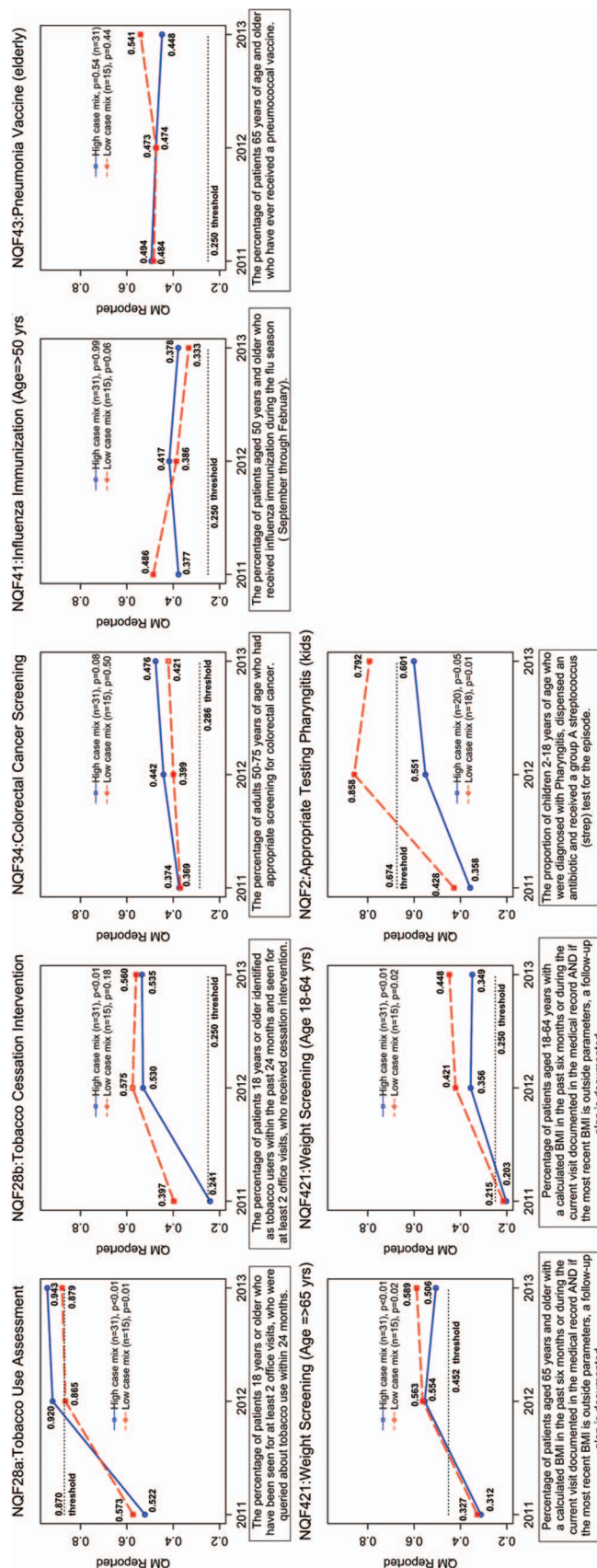
practices with a high and low case mixes had significant increases in 5 of 12 and 6 of 12 reported metrics, respectively: chicken pox, hepatitis B, combination 1 (low case-mix practices only); measles, mumps, and rubella and pneumococcal conjugate (high case-mix practices only); and polio, *Haemophilus influenza* type B, and rotavirus (all practices). All metrics, with 6 starting below the achievement threshold in the baseline year, had values surpassing or within an acceptable range of the achievement threshold by 2013.

Of the remaining 8 quality metrics from the preventive care domain most relevant to adults (Appendix Figure 4), the following had an increase among practices with a high and low case mix: tobacco cessation intervention, colorectal cancer screening (high case-mix practices only), tobacco use assessment, weight screening for those ages 18 to 64 years, weight screening for those ≥65 years old, and appropriate testing for pharyngitis in children (all high and low case-mix practices). All metrics had surpassed or were within an acceptable range of the quality achievement range by 2013. Interestingly, we observed a significant trend for lower reported rates of influenza immunization among practices with a low case mix.

The mental health care domain (Appendix Figure 5) had the largest significant increase over the measurement period; both practices with a high case mix and those with a low case mix starting in the baseline year well below the achievement threshold for antidepressant treatment rates at 84 and 180 days after the diagnosis of major depression surpassed the threshold criterion by 2013.

Appendix Figure 4. Preventive care domain (remaining metrics): average National Quality Forum (NQF) quality metrics (QM) scores reported over the years 2011 to 2013, stratified by practices with high and low case mixes. *P* **values designate statistical significance of the average total change from 2011 to 2013.**

Appendix Figure 5. Health care domain: average quality metrics (QM) scores reported over the years 2011 to 2013, stratified by practices with high and low case mixes. *P* values designate statistical significance of the average total change from 2011 to 2013.

NQF105: Antidepressants =>84 days post dx

The percentage of patients 18 years of age and older who were diagnosed with a new episode of major depression, dispensed antidepressant medication =>84 days after diagnosis, and who remained on an antidepressant medication treatment.

High case mix (n=31), p<0.01
Low case mix (n=15), p<0.01

0.662 threshold
0.304
0.293
0.667
0.624
0.752
0.679

NQF105:Antidepressants=>180 days post dx

The percentage of patients 18 years of age and older who were diagnosed with a new episode of major depression, dispensed antidepressant medication =>180 days after diagnosis, and who remained on an antidepressant medication treatment.

High case mix (n=31), p<0.01
Low case mix (n=15), p<0.01

0.526 threshold
0.250
0.233
0.590
0.509
0.644
0.618