Association between Temporal Changes in Primary Care Workforce and Patient Outcomes

Chiang-Hua Chang, A. James O'Malley, and David C. Goodman

Objective. To examine the association between 10-year temporal changes in the primary care workforce and Medicare beneficiaries' outcomes.

Data Sources. 2001 and 2011 American Medical Association Masterfiles and fee-for-service Medicare claims.

Study Design/Methods. We calculated two primary care workforce measures within Primary Care Service Areas: the number of primary care physicians per 10,000 population (per capita) and the number of Medicare primary care full-time equivalents (FTEs) per 10,000 Medicare beneficiaries. The three outcomes were mortality, ambulatory care-sensitive condition (ACSC) hospitalizations, and emergency department (ED) visits. We measured the marginal association between changes in primary care workforce and patient outcomes using Poisson regression models.

Principal Findings. An increase of one primary care physician per 10,000 population was associated with 15.1 fewer deaths per 100,000 and 39.7 fewer ACSC hospitalizations per 100,000 (both $p < .05$). An increase of one Medicare primary care FTE per 10,000 beneficiaries was associated with 82.8 fewer deaths per 100,000, 160.8 fewer ACSC hospitalizations per 100,000, and 712.3 fewer ED visits per 100,000 (all $p < .05$).

Conclusions. Medicare beneficiaries' outcomes improved as the number of primary care physicians and their clinical effort increased.

Key Words. Primary care workforce, Medicare, patient outcomes, change over time

Many policy makers and providers are concerned about the readiness of the U.S. physician workforce to meet a greater demand for primary care that is expected with the full implementation of the Affordable Care Act (ACA) (Bodenheimer and Pham 2010; Iglehart 2011; Okie 2012; Auerbach et al. 2013; Council on Graduate Medical Education 2010, 2013; Huang and

Finegold 2013; Shipman and Sinsky 2013). With insurance expansion underway, the demand for primary care clinicians is expected to increase.

The adequacy of the primary care workforce to meet the needs of Americans has been debated for decades (Goodman 2004; Starfield, Shi, and Macinko 2005; Salsberg and Grover 2006; Macinko, Starfield, and Shi 2007; Colwill, Cultice, and Kruse 2008; Goodman and Fisher 2008; Boulton et al. 2010; Friedberg, Hussey, and Schneider 2010; Phillips and Bazemore 2010; Starfield 2010; Council on Graduate Medical Education 2010). Forecasts of a primary care clinician shortage have generally assumed that there is a “right rate” of local primary care capacity and that patients will benefit from a larger primary care workforce, even if the ideal supply is unknown (Salsberg and Grover 2006; Colwill, Cultice, and Kruse 2008; Huang and Finegold 2013). A related assumption of these supply and demand models is that increasing the level of the primary care workforce improves patient outcomes (Starfield, Shi, and Macinko 2005; Friedberg, Hussey, and Schneider 2010; Council on Graduate Medical Education 2010). Evidence to support these assertions, however, is limited (Shi et al. 2003, 2005c). Most previous studies of the effects of the size of the primary care workforce were based on cross-sectional designs and did not examine the effects of workforce change over time (Shi et al. 2005b; Chang et al. 2011; Agency for Healthcare Research and Quality 2012). While these previous results have generally shown that patients in areas with high levels of primary care workforce have better outcomes, the effect sizes are relatively small. For example, using 2007 Medicare data, Chang et al. (2011) found a 5 percent reduction in mortality and 9 percent fewer ACSC hospitalizations for Medicare beneficiaries residing in areas with 60 percent higher primary care workforce (i.e., in the areas with highest compared to lowest quintile of area supply). Achieving the supply associated with these full benefits would require an additional 111,000 primary care physicians, a 66 percent increase in the 2007 total number of primary care physicians (see Appendix SA4).

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The studies of initiatives to increase the number of primary care physicians in low-supply areas have generally focused on physician recruitment, but not associated patient outcomes (Rabinowitz et al. 1999, 2011; Pathman et al. 2006a; Odom Walker et al. 2010). The lone study (Shi et al. 2005c) to directly measure the association between changes in primary care physician supply and mortality is based on data from over 20 years ago and was limited to state-level data, which do not accurately reflect the local availability of primary care physicians (Shipman et al. 2011).

In this study, we examined the association between temporal changes in the adult primary care (family/general practice and general internal medicine) workforce and Medicare patient outcomes between 2001 and 2011 using two measures of workforce at the level of Primary Care Service Areas (PCSAs, $N = 6,542$) (Goodman et al. 2003; Chang et al. 2011). The first was the number of adult primary care physicians per 10,000 population (per capita measure), derived from the American Medical Association (AMA) Masterfile. The AMA Masterfile is the commonly used data source for assessing the adequacy of physician supply in an area. The second measure was the number of Medicare clinical primary care full-time equivalents per 10,000 beneficiaries (FTE measure), derived from Medicare adult primary care physician claims data, to represent the clinical effort of primary care physicians delivered to Medicare beneficiaries in the areas. PCSAs are a group of standardized primary care markets developed with Medicare data that have been used to measure local primary care activity and study access to care (Pathman, Ricketts, and Konrad 2006b; Lowe et al. 2009; Butler et al. 2013; Huang and Finegold 2013). We used fee-for-service (FFS) Medicare claims to measure patient outcomes. We hypothesized that temporal changes in both primary care workforce measures were associated with patient outcomes and that this association was stronger with the FTE measure, which estimates primary care clinical labor input (Chang et al. 2011). Specifically, beneficiaries living in areas with increased workforce would experience fewer deaths, fewer hospitalizations for ambulatory care-sensitive conditions (ACSC), and fewer emergency department (ED) visits.

METHODS

Study Populations

We identified our study populations from the 20 percent 2001 and 2011 Medicare Denominator files. For each year, we selected beneficiaries who enrolled

as FFS (i.e., not Medicare Advantage), resided in the United States, were age 65–99 on January 1, and had both Part A and Part B coverage. We assigned each beneficiary to a PCSA based on his/her residential ZIP code. The number of study beneficiaries was 5,119,983 for 2001 and 5,131,140 for 2011.

Adult Primary Care Workforce Measures in PCSAs

We calculated two adult primary care workforce measures in PCSAs for 2001 and 2011 as described previously (Chang et al. 2011). In brief, for the per capita measure, we first used the AMA Masterfile to identify office-based, nonfederal family/general practice physicians, and general internists who had completed postgraduate medical education, were age 26–65 years, and practiced in the United States ($N = 136,079$ for 2001 and $N = 162,056$ for 2011). We then assigned each primary care physician to a PCSA based on his/her office ZIP code (90 percent), or when not available, the physician's preferred mailing address ZIP code. We calculated primary care physicians per capita in each PCSA according to the indirect adjustment method, adjusting for specialty-specific patient age and sex (Goodman et al. 1996; Chang et al. 2011).

For the Medicare primary care FTE measure, we selected office- or clinic-based evaluation and management (E&M) visit claims of family/general practice physicians and general internists of study beneficiaries from both the Part B (CPT codes: 99201–99205, 99211–99215, 99381–99387, 99391–99397) and Outpatient files (the Outpatient files includes office visits provided at rural health centers and federally qualified health centers) of our FFS study beneficiaries. Physician specialties were determined from the line item claims as reported to Medicare. We then linked the claims' CPT and modifier codes to work Relative Value Units (wRVUs) using the Medicare Physician Fee Schedule published by the Center for Medicare and Medicaid Services. There were 139,284 unique primary care providers in 2001 and 144,439 in 2011 for our study beneficiaries, a 3.7 percent increase. We then aggregated their E&M claims wRVUs to beneficiaries' PCSAs by specialty. We converted area wRVUs to area FTEs based on the number of wRVUs per FTE per year by specialty derived from two large surveys of medical clinics (2001: 4,139 wRVUs per FTE for family/general practice physicians and 3,856 wRVUs per FTE for general internists; 2011: 4,899 wRVUs per FTE for family/general practice physicians and 4,846 wRVUs per FTE for general internists) to represent the total amount of Medicare primary care clinical effort delivered to the area's FFS Medicare beneficiaries (Goodman et al. 2006). We standardized the PCSA-level Medicare primary care FTE

measure by patients' age, sex, and race using the indirect adjustment method (Chang et al. 2011).

Patient-Level Outcomes

We calculated patient-level outcomes for 2001 and 2011 separately. Mortality was identified from the Medicare Denominator files. We also studied two utilization measures that have been used to evaluate access to primary care—ACSC hospitalizations (Billings 2003; Laditka, Laditka, and Probst 2005) and ED visits (Lowe et al. 2009; Sharma et al. 2010). ACSC hospitalizations and ED visits are regarded as largely preventable when adequate access to primary care and timely ambulatory care are provided (Billings 2003; Laditka, Laditka, and Probst 2005; Lowe et al. 2009; Sharma et al. 2010).

Hospitalization claims of study beneficiaries with any of 12 ACSCs (convulsions, chronic obstructive pulmonary disease, pneumonia, asthma, congestive heart failure, hypertension, angina, cellulitis, diabetes, gastroenteritis, kidney/urinary infection, and dehydration) occurring in acute care hospitals were identified from the Medicare Provider Analysis and Review (MedPAR) file (Billings 2003; Chang et al. 2011). Visits to EDs were identified from the hospital claims (MedPAR, with ED payment) or Outpatient claims (revenue center code: emergency room 0450–0459, professional fee—emergency room 0981) (Sharma et al. 2010).

Other Covariates

We included both individual risk factors and area-level resources that previous studies suggested were related to either workforce or outcomes (Wennberg et al. 2004; Shi et al. 2005c; Goodman et al. 2006; Chang et al. 2011). Individual risk factors included age (65–69, 70–74, 75–79, 80–84, 85+), sex, race (black vs. non-black), and the presence of diagnoses of chronic conditions that are strongly associated with mortality from both inpatient and outpatient claims (cancer, congestive heart failure, chronic pulmonary disease, dementia, diabetes, peripheral vascular disease, renal failure, severe liver disease, and coronary artery disease) (Goodman et al. 2006; Wennberg et al. 2008). The area-level covariates were median household income (ZIP code areas), medical specialty supply (hospital service areas), and hospital bed supply (hospital service areas) that were developed by the PCSA Project (Goodman et al. 2003). Hospital service areas are aggregated of PCSAs to represent geographic markets for inpatient care (Chang et al. 2011).

Statistical Analysis

The primary goal of the statistical analysis was to determine whether patient outcomes were better in areas that experienced a growth in workforce—either the per capita or FTE measure—after controlling for all observed covariates that could confound the relationship between changes in workforce and patient outcomes. We first calculated primary care workforce measures for 2001 and 2011, then the changes in these for each PCSA. Analogous calculations were performed for all patient- and area-level covariates. We analyzed the effect of change in the workforce on changes in outcomes of the 2011 study population, adjusting for 2001 workforce, changes in area-level covariates and patient characteristics.

Estimated Associations with Outcomes

We used Poisson regression models to estimate the association between change in workforce (per 10,000 individuals in the PCSA) and outcomes (per 100,000 beneficiaries). The regression coefficient of the change in workforce is interpreted as the effect of a “one-unit change” in the workforce, which was defined as an increase of primary care physicians/FTEs by 1 for every 10,000 individuals in the area; equivalently an increase of 10 primary care physicians/FTEs for every 100,000 or 0.1 primary care physicians/FTEs per every 1,000 individuals. Because the prevalence of annual death is low (about 5 percent of study beneficiaries), the exponential of the coefficient closely approximates the population-level risk ratio of the probability of dying within 1 year under a one-unit increase in the workforce compared to no increase in workforce.

To account for the possible clustering of outcomes within areas, we allowed the variance of outcome counts to be over-dispersed relative to that of the Poisson distribution using the GENMOD procedure in SAS to estimate the associated effects with robust (nonmodel-based) standard errors.

For the adjusted associations, we included several covariates in the models to adjust for potential confounders. To account for the fact that patient characteristics and area resources may have changed both between areas and over time, the area-level changes (2011 less 2001) and the 2001 values of each covariate at the PCSA level were included. To account for the outcomes in each area in 2001, both the area-level mean outcomes and workforce measures in 2001 were also included. Finally, to account for within-area differences between beneficiaries in 2011, the covariates of each individual in the 2011

study population were included as individual-level covariates. Because primary care is a portion of the total care that patients receive, we included medical specialty supply and hospital bed supply at the level of the hospital service area. We included hospital bed supply in the models for ACSC hospitalizations and ED visits but not for annual mortality (Chang et al. 2011). Lastly, we included ZIP code area-level median household income and the PCSA-level urban indicator to account for income inequalities and health needs between urban and nonurban areas (Shi et al. 2005a).

All analyses were conducted using *SAS V9.3* (SAS Institute Inc., Cary, NC, USA). The Dartmouth College Institutional Review Board approved this study.

RESULTS

Characteristics of Study Populations in 2001 and 2011

During the period from 2001 to 2011, overall mortality decreased 8.8 percent from 5,609.9 to 5,115.6 per 100,000 beneficiaries ($p < .05$). There were also 17 percent fewer ACSC hospitalizations (8,280.4 vs. 6,852.8 per 100,000 beneficiaries, $p < .05$) but a 41 percent increase in ED visits (38,411.2 vs. 54,275.4 per 100,000 beneficiaries, $p < .05$) (Table 1). At the same time, there were a higher proportion of beneficiaries under age 70 and over age 85 (25.1 percent vs. 28.5 percent, 13.1 percent vs. 15.2 percent, respectively, $p < .05$), and more beneficiaries had chronic conditions (35.5 percent vs. 38.2 percent, $p < .05$).

Primary Care Workforce at the PCSA Level in 2001 and 2011

Between 2001 and 2011, the number of adult primary care physicians per population increased 10 percent, from 4.8 primary care physicians to 5.3 primary care physicians per 10,000 population, while Medicare primary care FTEs per beneficiary increased 24 percent, from 6.6 primary care FTEs to 8.2 primary care FTEs per 10,000 beneficiaries (Table 2). At the PCSA level, the variation of the workforce in 2001 and 2011 was similar (interquartile ratios 2.5 and 2.8 for the per capita measure and 1.3 and 1.3 for the FTE measure, respectively). The variation in the change of workforce between 2001 and 2011 across PCSAs, however, was striking. The interquartile (75th percentile and the 25th percentile) differences per 10,000 in workforce at the

Table 1: Characteristics of 20% Medicare Fee-for-Service Beneficiaries between 2001 and 2011

	2001	2011	
Total	5,119,983	5,131,140	
Mean age	75.5	75.5	
Average median household income*	\$44,646	\$56,502	
Age 65–69	1,283,738 (25.1)	1,462,388 (28.5)	
Age 70–74, <i>N</i> (%)	1,277,848 (25.0)	1,177,210 (22.9)	
Age 75–79, <i>N</i> (%)	1,118,464 (21.8)	941,407 (18.3)	
Age 80–84, <i>N</i> (%)	770,480 (15.0)	769,516 (15.0)	
Age 85–99, <i>N</i> (%)	669,453 (13.1)	780,619 (15.2)	
Female, <i>N</i> (%)	3,050,800 (59.6)	2,939,226 (57.3)	
Black, <i>N</i> (%)	391,185 (7.6)	389,179 (7.6)	
Chronic conditions [†] , <i>N</i> (%)	1,816,853 (35.5)	1,958,146 (38.2)	
Multiple chronic conditions [†] , <i>N</i> (%)	527,212 (10.3)	628,154 (12.2)	
Residing in urban areas [‡] , <i>N</i> (%)	3,674,569 (71.8)	3,760,719 (73.3)	
Outcomes			Difference per 100,000
Mortality per 100,000 beneficiaries	5,609.9	5,115.6	–494.3
Hospitalizations for ambulatory care–sensitive conditions per 100,000 beneficiaries	8,280.4	6,852.8	–1,427.6
Total emergency department visits per 100,000 beneficiaries	38,411.2	54,275.4	15,864.2

Note. All comparisons were statistically significant at $p < .05$.

*2000 and 2009 estimates from the Primary Care Service Project.

[†]Modified nine Iezzoni chronic conditions: cancer, congestive heart failure, chronic pulmonary disease, dementia, diabetes, peripheral vascular disease, renal failure, severe liver disease, and coronary artery disease.

[‡]Urban or suburban Rural Urban Community Areas.

PCSA level were –0.8 to 1.1 for the per capita measure and 0.4 to 2.2 for the FTE measure.

Unadjusted Associations between Outcomes and Workforce

Table 3 shows unadjusted associations between change in workforce and outcomes. Without adjustment, compared to 2001 outcomes, an increase of one adult primary care physician per 10,000 population was associated with a reduction of 105.6 ACSC hospitalizations but an increase of 72.0 ED visits per 100,000 beneficiaries in 2011 (all $p < .05$). The corresponding associated changes in outcomes for the primary care FTE measure were 176.9 more ACSC hospitalizations and 179.4 more ED visits per 100,000 beneficiaries (all $p < .05$). There were no significant associations with mortality for either workforce measure ($p > .05$).

Table 2: 2001 and 2011 Adult Primary Care Physician Workforce in the United States

<i>Among 6,542 Primary Care Service Areas</i>							
	<i>U.S. Average</i>	<i>5th Percentile</i>	<i>25th Percentile</i>	<i>Median</i>	<i>75th Percentile</i>	<i>95th Percentile</i>	<i>Interquartile Ratio</i>
Primary care physicians per 10,000 population*							
2001	4.8	0.0	2.1	3.6	5.1	8.4	2.5
2011	5.3	0.0	1.9	3.7	5.4	9.1	2.8
Difference	0.5	−3.5	−0.8	0.02	1.1	3.6	1.9
Medicare primary care full-time equivalents per 10,000 beneficiaries†							
2001	6.6	4.5	5.7	6.5	7.4	9.0	1.3
2011	8.2	4.4	6.7	7.8	8.9	10.8	1.3
Difference	1.6	−2.1	0.4	1.4	2.2	3.7	1.8

Note. *Age–sex-adjusted office-based American Medical Association Masterfile clinically active primary care physicians per 10,000 population.

†Age–sex–race-adjusted office-based primary care full-time equivalents per 10,000 of study beneficiaries.

Adjusted Associations between Outcomes and Workforce

After adjusting for covariates, as Table 4 shows, changes in the primary care workforce were significantly and inversely (i.e., lower the risk ratio) related to outcomes except that no association was observed between the per capita workforce measure and ED visits. Each increase of one primary care physician per 10,000 population was associated with 15.1 fewer deaths and 39.7 fewer ACSC hospitalizations per 100,000 Medicare beneficiaries. Each increase in one primary care FTE was associated with 82.8 fewer deaths, 160.8 fewer ACSC hospitalizations, and 712.3 fewer ED visits per 100,000 Medicare beneficiaries (all $p < .05$).

We further examined whether the associations differed according to the baseline (2001) workforce level by adding an interaction between the 2001 workforce and the change in workforce (Table 4). Among the six models (two workforce measures and three outcomes), three had a significant interaction effect. For the per capita measure, the only significant interaction effect was for ED visits (risk ratio = 1.0001, $p = .042$). There was a similar interaction effect for the FTE measure for ED visits (risk ratio = 1.0008, $p = .017$). In addition, there was a significant interaction effect for ACSC hospitalizations (risk ratio = 0.998, $p = .010$). Despite the significant interactions for ED visits and ACSC hospitalizations, the magnitude of their effect was small compared to that of the main effect and so would be unlikely to be considered clinically significant.

Table 3: Unadjusted Associations between Change in Primary Care Workforce and 2011 Outcomes

	Results from Unadjusted Models (per Beneficiary)							
	Mortality			Hospitalizations for Ambulatory Care-Sensitive Conditions			Total Emergency Department Visits	
	Risk Ratio	95% CI	p-value	Risk Ratio	95% CI	p-value	Risk Ratio	p-value
Workforce measure								
An increase of one primary care physicians per 10,000 population [†]	1.001	(0.999–1.004)	.329	0.987	(0.985–0.990)	<0.05	1.002	(1.001–1.003) <05
Based on 2001 U.S. average by increase 1 per 10,000 workforce	Associated increase of 7.2 per 100,000			Associated reduction of 105.6 per 100,000			Associated increase of 72.0 per 100,000	
An increase of one Medicare primary care full-time equivalents per 10,000 beneficiaries [‡]	0.997	(0.993–1.000)	.058	1.021	(1.018–1.024)	<0.05	1.005	(1.003–1.006) <05
Based on 2001 U.S. average by increase 1 per 10,000 workforce	Associated reduction of 18.0 per 100,000			Associated increase of 176.9 per 100,000			Associated increase of 179.4 per 100,000	

Note. To calculate associated change, for example, we applied the annual mortality for 2001 of 5,610 per 100,000 from Table 1 to compute the reduction in the number of deaths per 100,000 as: $5,610 \times (1 - 1.001291) = -7.24$ for per capita measure; $5,610 \times (1 - 0.996797) = 17.97$ for full-time equivalents measure.

The risk ratios show the direction of change.

If the value of risk ratio is >1 , then adding workforce is associated with an increased outcome.

If the value of risk ratio is <1 , then adding workforce is associated with a decreased outcome.

[†]Age-sex-adjusted office-based American Medical Association Masterfile clinically active primary care physicians per 10,000 total population.

[‡]Age-sex-race-adjusted office-based primary care full-time equivalents per 10,000 study beneficiaries.

Table 4: Adjusted Associations between Change in Primary Care Workforce and 2011 Outcomes

	Results from Unadjusted Models (per Beneficiary)							
	Mortality			Hospitalizations for Ambulatory Care–Sensitive Conditions			Total Emergency Department Visits	
	Risk Ratio	95% CI	p-value	Risk Ratio	95% CI	p-value	Risk Ratio	95% CI
Workforce measure								
Main model								
An increase of one primary care physicians per 10,000 population †	0.997	(0.995–1.000)	.045	0.995	(0.993–0.998)	<0.05	1.001	(1.000–1.002)
Associated changes based on 2001 U.S. average by increase 1 per 10,000 workforce	Associated reduction of 15.1 per 100,000			Associated reduction of 39.7 per 100,000			Associated increase of 24.4 per 100,000	
Model with interaction term								
An increase of one primary care physicians per 10,000 population †	0.995	(0.991–0.999)	<.05	0.994	(0.990–0.997)	<0.05	1.000	(0.998–1.001)
2001 × difference in primary care physicians per 10,000 population	1.000	(1.000–1.001)	.206	1.000	(1.000–1.001)	0.352	1.0001	(1.0000–1.0003)
Main model								
An increase of one Medicare primary care full-time equivalents per 10,000 beneficiaries ‡	0.985	(0.982–0.989)	<.05	0.981	(0.978–0.983)	<0.05	0.981	(0.980–0.983)

Continued

Table 4. *Continued*

	<i>Results from Unadjusted Models (per Beneficiary)</i>							
	<i>Mortality</i>				<i>Hospitalizations for Ambulatory Care—Sensitive Conditions</i>			
	<i>Risk Ratio</i>	<i>95% CI</i>	<i>p-value</i>		<i>Risk Ratio</i>	<i>95% CI</i>	<i>p-value</i>	
Associated changes based on 2001 U.S. average by increase 1 per 10,000 workforce	Associated reduction of 82.8 per 100,000				Associated reduction of 160.8 per 100,000			Associated reduction of 712.3 per 100,000
Model with interaction term								
An increase of one Medicare primary care full-time equivalents per 10,000 beneficiaries [‡]	0.982	(0.968–0.995)	<.05		0.995	(0.984–1.006)	0.345	0.976 (0.972–0.981)
2001 × difference in Medicare primary care full-time equivalents per 10,000 beneficiaries	1.001	(0.999–1.002)	.581		0.998	(0.996–1.000)	<0.05	1.0008 (1.0001–1.0014)

Note. To calculate associated change, for example, we applied the annual mortality for 2001 of 5,610 per 100,000 from Table 1 to compute the reduction in the number of deaths per 100,000 as: $5,610 \times (1 - 0.9973) = 15.14$ for per capita measure; $5,610 \times (1 - 0.9852) = 82.76$ for full-time equivalents measure.

The risk ratios show the direction of change.

If the value of risk ratio is >1 then adding workforce is associated with an increased outcome.

If the value of risk ratio is <1, then adding workforce is associated with a decreased outcome.

*Adjusted for 2011 individual patient characteristics (age, sex, race, chronic conditions), 2001 area patient characteristics, difference in area patient characteristics, 2001 area outcome, 2001 workforce, and area urban indicator, area median household income, area specialty supply, and area hospital bed supply (hospitalizations and emergency department visits).

[‡]Age–sex-adjusted office-based American Medical Association Masterfile clinically active primary care physicians per 10,000 total population.

*Age–sex–race-adjusted office-based primary care full-time equivalents per 10,000 study beneficiaries.

Table 5: Adjusted Associations between Change in Primary Care Workforce and 2011 Outcomes by Quintile of 2001 Primary Care Workforce

Workforce Measure	Quintile ^c of 2001 Workforce (Median)	Results from Adjusted Models (per Beneficiary) ^a									
		Mortality			Hospitalizations for Ambulatory Care-Sensitive Conditions			Total Emergency Department Visits			
		Risk Ratio	95% CI	p-value	Risk		p-value	Risk		p-value	
					Ratio	95% CI		Ratio	95% CI		
An increase of one primary care physicians per 10,000 population ^d	Lowest (1.7)	0.998	(0.991–1.005)	.570	0.998	(0.992–1.003)	.391	1.001	(0.999–1.003)	.481	
	2 (3.5)	0.997	(0.989–1.005)	.501	0.997	(0.991–1.004)	.457	0.999	(0.996–1.001)	.285	
	3 (4.4)	0.990	(0.983–0.998)	<.05	0.995	(0.989–1.001)	.114	1.001	(0.999–1.003)	.434	
	4 (5.3)	0.998	(0.991–1.005)	.624	0.996	(0.990–1.002)	.191	0.998	(0.996–1.001)	.216	
	Highest (7.5)	1.000	(0.995–1.004)	.873	0.993	(0.989–0.996)	<.05	1.004	(1.003–1.006)	<.05	
An increase of one medicare primary care full-time equivalents per 10,000 beneficiaries ^e	Lowest (5.1)	0.988	(0.980–0.997)	<.05	0.997	(0.990–1.004)	.374	0.990	(0.988–0.993)	<.05	
	2 (6.0)	0.986	(0.977–0.995)	<.05	0.973	(0.965–0.980)	<.05	0.976	(0.973–0.979)	<.05	
	3 (6.5)	0.984	(0.975–0.993)	<.05	0.982	(0.974–0.989)	<.05	0.982	(0.979–0.985)	<.05	
	4 (7.1)	0.978	(0.970–0.985)	<.05	0.973	(0.967–0.979)	<.05	0.975	(0.972–0.977)	<.05	
	Highest (8.1)	0.988	(0.982–0.995)	<.05	0.981	(0.975–0.986)	<.05	0.983	(0.981–0.985)	<.05	

Note. The risk ratios show the direction of change.
If the value of risk ratio is >1, then adding workforce is associated with an increased outcome.
If the value of risk ratio is <1, then adding workforce is associated with a decreased outcome.
*Adjusted for 2011 individual patient characteristics (age, sex, race, chronic conditions), 2001 area patient characteristics, difference in area patient characteristics, 2001 area outcome, 2001 workforce, and area urban indicator, area median household income, area specialty supply, and area hospital bed supply (hospitalizations and emergency department visits).
†Equal-population size.
‡Age-sex-adjusted office-based American Medical Association Masterfile clinically active primary care physicians per 10,000 total population.
§Age-sex-race-adjusted office-based primary care full-time equivalents per 10,000 study beneficiaries.

Because the distribution of change in workforce is skewed (Table 2), we also classified each area according to equal-population quintiles of the 2001 workforce to examine the effects of association between change in primary care workforce and outcomes (Table 5). For the six stratified models, we found two significant results: a reduction in mortality and ED visits for the FTE measure (for quintiles 1–5, risk ratios for mortality: 0.988, 0.986, 0.984, 0.978, and 0.988, respectively; for ED visits: 0.990, 0.976, 0.982, 0.975, and 0.983, respectively, all $p < .05$). Given the apparent nonmonotonic trend in the effects across the quintiles, the statistical tests of whether the associated effects for mortality and ED visits varied linearly across the quintiles were not significant ($p > .05$). These results were consistent with our earlier nonsignificant findings of lack of clinical significance for the interaction of 2001 level and change measures for primary care physician supply and FTEs.

Sensitivity of Results to Model Specification

As a sensitivity analysis to test our model specification, an alternative approach would be to first estimate separate fixed effects models for 2001 and 2011, adjusting for both patient and area covariates and weighting by the corresponding study population to obtain the adjusted outcomes for each area and each year. Then perform an area-level difference-in-differences model to estimate the change in the adjusted outcomes (2011 less 2001) on the change in the workforce measure (2011 less 2001). The advantage of this more elaborate approach is that the separately estimated fixed effects estimates would allow for the possibility that patient covariates may have had a different relationship with outcomes across the years and would also yield more precise estimates of the area's adjusted mean outcome.

Due to the large number of areas with small numbers of beneficiaries in our sample, we encountered numerical problems getting the fixed effect models in the first step to converge. We overcame this problem by restricting the sample to areas with 600 or more beneficiaries, encompassing 2,050 PCSAs and representing 71.5 percent of the 2001 study population and 78.6 percent of the 2011 study population. Because of the failure to use the full sample, we regard this analysis as a valuable sensitivity analysis as opposed to a primary analysis.

To evaluate the adequacy of the original approach, which used area-level predictors as opposed to fixed effects, we compared the results it obtained to those from the reduced dataset for the per capita measure and mortality. The results were similar between the two approaches (Appendix SA2), and also

similar to those using the entire data. The similarity of these findings led us to conclude that the findings of our primary analysis were robust.

Although our models included an area's urban indicator, this may not be sensitive to the distinction between small towns and isolated rural areas. Therefore, we reran the main analysis stratifying areas into urban core, suburban, large town, small town, and isolated rural based on the rural urban commuting area classification. The results were similar to the stratification analyses based on quintiles of 2001 workforce (Appendix SA3), confirming that our results were robust to the adjustment for rurality.

Comparison of Observed Effects to Secular Trends

Given that mortality declined over the study period, we calculated the proportion of mortality decline that could be attributed to change in primary care physician supply. First (#1), we obtained the difference of overall deaths per 100,000 Medicare beneficiaries between 2001 and 2011 from Table 1. Then (#2), we calculated the number of deaths reduced per increase in primary care physician supply by taking the U.S. average difference in primary care physicians per 10,000 between 2001 and 2011 (Table 2) and multiplying by our model estimates of the change in deaths per 100,000 per adding one primary care physician per 10,000 (Table 4). Lastly, we divided #2 by #1.

We found that less than 2 percent of the mortality decline could be attributed to the overall growth in primary care physicians per capita. If the number of primary care physicians per capita had doubled, then about 15 percent of the mortality decline would have been associated with higher primary care physician numbers (Appendix SA4).

DISCUSSION

We examined differences in the adult primary care workforce and associated Medicare patient outcomes between 2001 and 2011. Our main models showed a significant linear association between an increase in the primary care workforce and a reduction in mortality and ACSC hospitalizations for both workforce measures and a limited association for ED visits. We also found that the associations were much stronger (at least fourfold) for the FTE measure than the per capita measure. The association of change in the per capita measure on mortality is consistent with the previous state-level study by Shi et al.

(2005c), who found that one more primary care physician per 10,000 population was associated with a reduction of 14.4 deaths per 100,000.

The association of growth in the primary care workforce with better outcomes did not appear to be sensitive to the level of supply in 2001. The essentially nonsignificant interactions between the 2001 measures and the change in workforce between 2001 and 2011 indicated that the effects of change on outcomes after 10 years were not statistically different across areas with respect to the level of 2001 workforce. This finding was consistent with the results of our 2001 quintile-stratification analyses. Our results, based on three patient outcomes, suggest that increasing the primary care workforce might generally benefit Medicare populations, even in areas with a relative high level of primary care workforce.

We also found that the associated mortality effects were more than five times higher when using primary care office-based workforce effort. These differences could be explained by a number of factors. The AMA Masterfile measures physicians by self-reported specialty. Family medicine, internal medicine, and general practice trained physicians practice in diverse settings, with only a portion providing ambulatory-based primary care. Hospitalists and emergency room physicians, for example, are undercounted in the Masterfile, leading to falsely high estimates of primary care supply (American Medical Association 2011). The proportion of total primary care effort that is provided to Medicare beneficiaries can also vary widely by physician, and this can change over time.

One interpretation of the difference in the magnitude of associations by the type of primary care measure is that the effect of primary care is underestimated by the per capita measure. Another view is that these effects realistically estimate the impact of increased rates of training family physicians and general internists without assurances that these physicians will practice in ambulatory primary care. At the same time, the difference highlights the need for better funding of programs that increase the chances that these physicians will provide primary care services, such as the Teaching Health Center Graduate Medical Education (THCGME) program (<http://bhpr.hrsa.gov/grants/teachinghealthcenters/>). Regardless of the interpretation, training higher numbers of primary care physicians has proven difficult, not only because of limitations in public funding for graduate medical education but also because primary care remains less attractive to medical students (Council on Graduate Medical Education 2010, 2013). Furthermore, growth in the physician workforce is known to occur in urban, more affluent areas where need may be lower (Cull, Chang, and Goodman 2005; Council on Graduate Medical Education 2010,

2013). While our findings suggest that these populations might still benefit from an increased workforce, the settlement patterns may accentuate long-standing inequity in access.

Another factor that may temper the effects of changes in primary care physician supply may be the adaptation of populations and local health care systems. When a primary care physician leaves, other clinicians may be able to “pick up the slack” by increasing their efforts or reprioritizing their patients. Patients may defer less important reasons for seeing their primary care physicians or may seek care outside the local area. Increases in the primary care physician workforce may not have immediate effects on population health if the greater capacity is directed toward seeing patients who already have better health status, for example, younger and healthier adults. Sommers et al. (2014) found that, from January 2012 through June 2014, more than 10 million Americans aged 18–64 have gained health insurance coverage and, at the same time, more adults reported having a personal doctor while there is no evidence to suggest a rapid growth of primary care physicians entering into practice in the last 3 years.

We chose to study primary care supply specifically because of current policy advocacy to increase primary care training (Council on Graduate Medical Education 2010). It should be noted, however, that primary care training and practice are linked to a complex system of health workforce. In some instances, higher training of specialists in teaching hospitals is associated with lower primary care training (Salsberg et al. 2008). Other initiatives are directed solely at primary care training like THCGME. In our study, we controlled for specialist supply, but we did not examine its associations or the associations of the ratio of primary care to specialist supply. These are areas that merit future analysis.

One unexpected finding was the relatively stronger growth in the clinical primary care FTEs per beneficiary than in primary care physicians per capita. The number of unique primary care physicians who cared for Medicare patients increased by about only 4 percent. The wRVU for E&M visits set by the Medicare Physician Fee Schedule also increased in the last decade, which is reflected in the increase in the number of wRVUs per primary care FTE used in the clinical labor input measures. From this, one can surmise that there has been a trend of greater primary care effort per physician for Medicare beneficiaries. We cannot determine from this study whether this is caused by greater physician primary care productivity or a shifting of effort to the over 65 population.

Our study has several limitations. To identify primary care physicians and their practice locations, we used the AMA Masterfile, a physician census widely accepted for measuring the number of practicing physicians despite delayed updating of changes in specialty, clinical status, and practice location (Grumbach et al. 1995). We also assumed that all clinically active primary care physicians practiced with similar effort despite their specialty, years of experience, and size of their patient panel. We do not have comparable data for nurse practitioners, physician assistants, and other clinicians who are increasingly part of primary care teams (Kirch and Salsberg 2007; Bodenheimer and Pham 2010; Okie 2012), which might bias the workforce change measurement in some areas. Furthermore, several important attributes of patient-centered high-value primary care are not included in the workforce measure itself, such as coordination among providers, continuity and quality of the patient–physician relationship, and the process of disease management. We did not measure annual changes during the 10-year study period and our models cannot detect time-dependent associations of changed-value or lagged predictors. Our model analyses, although including both patient and area covariates, cannot adjust for unmeasured confounders. We used FFS Medicare beneficiaries as our study populations, and, therefore, our findings cannot be generalized to Medicare Advantage populations. In 2001, 18 percent of Medicare elderly beneficiaries were enrolled in Medicare Advantage plans, compared to 28 percent in 2011. It should be noted that the benefits of additional primary care physicians might extend to non-Medicare populations, including young adult patients where the effects may extend over decades. Finally, while PCSAs are the most specific health service areas available for analysis, not all beneficiaries receive their primary care from within-area providers, and are, therefore, “exposed” to a different supply level than measured in our analysis. This may decrease the observed association between primary care workforce and patient outcomes.

In conclusion, the U.S. healthcare landscape has experienced rapid changes since the ACA was enacted in 2010. Our findings suggest that increasing primary care supply could improve patient outcomes, supporting the reform proposals advocated since the 1970s with primary care as the backbone to improving the health care delivery system (Starfield 1992; Donaldson et al. 1996). Our findings also support the idea that clinical effort provided by primary care physicians is more important than the headcount of local primary care physicians for better patient outcomes. The magnitude of these primary care supply effects is important, but relatively small in relation to secular trends.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.

Appendix SA2: Adjusted Associations between Change in Primary Care Workforce and 2011 Outcomes Based on Areas with at Least 600 Study Beneficiaries for Both Years.

Appendix SA3: Adjusted Associations between Change in Primary Care Workforce and 2011 Outcomes by Rural Urban Commuting Area.

Appendix SA4: Estimation of the Magnitude of Associations of Primary Care Physicians on Mortality in Relation to Secular Trends.