Primary Care Physician Workforce and Medicare Beneficiaries' Health Outcomes

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Context Despite a widespread interest in increasing the numbers of primary care physicians to improve care and to moderate costs, the relationship of the primary care physician workforce to patient-level outcomes remains poorly understood.

Objective To measure the association between the adult primary care physician workforce and individual patient outcomes.

Design, Setting, and Participants A cross-sectional analysis of the outcomes of a 2007 20% sample of fee-for-service Medicare beneficiaries aged 65 years or older (N=5 132 936), which used 2 measures of adult primary care physicians (general internists and family physicians) across Primary Care Service Areas (N=6542): (1) American Medical Association (AMA) Masterfile nonfederal, office-based physicians per total population and (2) office-based primary care clinical full-time equivalents (FTEs) per Medicare beneficiary derived from Medicare claims.

Main Outcome Measures Annual individual-level outcomes (mortality, ambulatory care sensitive condition [ACSC] hospitalizations, and Medicare program spending), adjusted for individual patient characteristics and geographic area variables.

Results Marked variation was observed in the primary care physician workforce across areas, but low correlation was observed between the 2 primary care workforce measures (Spearman r=0.056; $P<.001$). Compared with areas with the lowest quintile of primary care physician measure using AMA Masterfile counts, beneficiaries in the highest quintile had fewer ACSC hospitalizations (74.90 vs 79.61 per 1000 beneficiaries; relative rate [RR], 0.94; 95% confidence interval [CI], 0.93-0.95), lower mortality (5.38 vs 5.47 per 100 beneficiaries; RR, 0.98; 95% CI, 0.97-0.997), and no significant difference in total Medicare spending ($8722 vs $8765 per beneficiary; RR, 1.00; 95% CI, 0.99-1.00). Beneficiaries residing in areas with the highest quintile of primary care clinician FTEs compared with those in the lowest quintile had lower mortality (5.19 vs 5.49 per 100 beneficiaries; RR, 0.95; 95% CI, 0.93-0.96), fewer ACSC hospitalizations (72.53 vs 79.48 per 1000 beneficiaries; RR, 0.91; 95% CI, 0.90-0.92), and higher overall Medicare spending ($8857 vs $8769 per beneficiary; RR, 1.01; 95% CI, 1.004-1.02).

Conclusion A higher level of primary care physician workforce, particularly with an FTE measure that may more accurately reflect ambulatory primary care, was generally associated with favorable patient outcomes.

JAMA. 2011;305(20):2096-2105 www.jama.com

STRENGTHENING THE ROLE OF PRIMARY care is a key element in most proposals to improve the outcomes and efficiency of health care delivery in the United States.[1,2] With the aging population and the waning interest in primary care by US medical school graduates, some have projected a large shortage of general internists and family physicians to care for a growing number of elderly patients.[3]

Many, but not all, previous studies have noted an association between higher primary care physicians per population and better health outcomes. For example, although states with higher primary care physicians per population were associated with lower mortality in 2 studies,[4,5] analyses at the county level have observed mixed associations.[6,7] Similarly, the associations observed in studies of ambulatory care sensitive condition (ACSC) hospitalizations and spending have been inconsistent.[8-10]

The lack of consistent associations between primary care physicians per population and patient outcomes raises questions about the population benefits of increased primary care training positions. Alternatively, the technical challenges in measuring primary care physician workforce and patient-level outcomes may have obscured real associations.

The physician workforce (ie, supply or capacity) is an ecological concept in research and public policy purposes that represents the number of physicians available for a given population in an area. To measure the number of physicians, most studies of the primary care physician workforce are based on headcounts of primary care physicians from the

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American Medical Association (AMA) Masterfile. Such counts may not accurately reflect the proportion of primary care trained physicians providing ambulatory primary care.[11] Physicians, for example, may be counted as primary care according to their self-designated specialty on the AMA Masterfile while practicing as hospitalists or emergency department physicians. In addition to using AMA Masterfile to measure the workforce, this study introduces a new measure of the ambulatory primary care workforce derived from Medicare claims to test hypotheses that high levels of primary care physician workforce are associated with lower mortality, fewer ACSC hospitalizations, and lower spending in Medicare beneficiaries.

METHODS

Study Population and Patient-Level Outcomes

We used a 20% national sample of fee-for-service Medicare beneficiaries and analyzed 100% of their physician and hospital claims. Beneficiaries were included if they resided in the United States, were aged 65 to 99 years on January 1, 2007, and had Part A (acute care in facilities, including hospitals) and Part B (clinician services) coverage in 2007 (N = 5 132 936). We assigned a Primary Care Service Area (PCSA) to each study beneficiary based on his/her resident zip code. The Dartmouth College institutional review board approved this study.

Death of study beneficiaries occurring in 2007 was identified from the Medicare Denominator file. Hospitalization claims of study beneficiaries for any of 12 ambulatory care sensitive conditions (convulsions, chronic obstructive pulmonary disease, pneumonia, asthma, congestive heart failure, hypertension, angina, cellulitis, diabetes, gastroenteritis, kidney or urinary infection, and dehydration) occurring in acute care hospitals were identified from the 2007 Medicare Provider Analysis and Review file by applying the Agency for Healthcare Research and Quality definition of ACSC hospitalizations.[12,13] Ambulatory care sensitive condition hospitalizations are regarded as largely preventable admissions when adequate and timely ambulatory care is provided. The Agency for Healthcare Research and Quality has used ACSC hospitalizations to monitor access, identify disparities, and assess performance of the safety net.[12]

We measured Medicare program payments by linking our study beneficiaries to a 5% sample (ie, 5% of all fee-for-service Medicare beneficiaries, which is one-fourth subset of our study population, n = 1 276 201) reported in the 2007 Continuous Medicare History Sample file. We classified Medicare program spending as either dollars spent on acute care facilities (Part A spending for acute facilities, such as inpatient and skilled nursing) or physician and other clinician payments (Part B spending for clinicians). Because of differences in cost of living, disproportionate share, graduate medical education, and hospital payments, Medicare reimbursements vary across areas. To adjust for such differences, we applied adjustment factors to obtain the price-adjusted Medicare spending for each beneficiary.[14]

Physician Workforce Measurement Unit

We used geographic service areas that reflect the use of primary care services as the units of primary care workforce exposure. The PCSAs (N = 6542) were defined by aggregating zip code areas to form primary care market areas based on travel of Medicare beneficiaries to primary care physicians, advanced nurse practitioners, and physician assistants for ambulatory primary care.[15] These areas are generally small geographic markets of primary care (median population, 15 470; median land area, 222 square miles) with low levels of patient border crossing.

Adult Primary Care Physician Workforce Measures

We developed 2 measures of adult primary care physician workforce, each consisting of family physicians and general internists. Briefly, the first measure was based on the AMA Masterfile data, the most widely used physician workforce data source.[4-7] The accuracy of this measure largely depends on physicians responding to surveys reporting their primary specialty (eg, general internist or hospitalist) and major professional activity (eg, office-based practice, hospital-based practice, or research). We refer to this workforce measure as primary care physicians per population.

The second workforce measure was an estimate of the ambulatory clinical full-time equivalents (FTEs) of primary care physicians and was derived from Medicare office- and clinic-based claims of primary care physicians.[16] We refer to this measure as primary care FTEs, although these comprise only FTEs related to Medicare claims, not all delivered medical care. In 2007, an estimated 27% of ambulatory care visits to office-based general internists and family physicians were for patients aged 65 years or older (available at ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Datasets/NAMCS/).

Primary Care Physicians per Population

Office-based, nonfederal family physicians and general internists who had postgraduate medical education, were aged 26 to 65 years, and practiced in the United States were identified from the 2007 AMA Masterfile (n = 155 729). The AMA Masterfile includes records for both allopathic and osteopathic physicians. Although we only included physicians who are engaged in more than 20 hours of professional activity per week (per self-reports), the AMA Masterfile does not have additional data to adjust for part-time clinical practice. To obtain the numerator of physician workforce, we counted primary care

physicians in each PCSA, where the PCSA practice locations were based on physicians' office zip code (90%), or when not available, the physician's preferred mailing address zip code. Population 2007 estimates based on the Census at the PCSA-level developed by the Primary Care Service Project were used as the denominator of the per population measure (available at http://www.dartmouth.edu/~cecs/pcsa/pcsa.html). We calculated the per population workforce according to the indirect adjustment method, adjusting for specialty-specific patient age and sex.[13,17] Because the unit of measurement is relatively small and primary care tends to be provided locally, this measure was not adjusted for migration of patients from their PCSA of residence to their PCSA of care.[18]

To test the sensitivity of the selection criteria used for this measure, we developed 3 additional AMA counts per population: (1) without specialty-specific patient age and sex adjustment, (2) including hospital-based physicians, and (3) including residents with a 0.35 discounted clinical effort.[17]

Primary Care FTEs

We first identified all office or clinic-based primary care claims of both family physicians and general internists from the Part B files (Current Procedure Terminology codes: 99201-99205, 99211-99215, 99241-99245, 99381-99387, 99391-99397, 99401-99404, 99411-99412, and 99420-99429) and outpatient files (all services provided at rural health centers and federally qualified health centers) of our study beneficiaries (17 686 471 claims). Physician specialty was determined from the line item claim as reported to Medicare. We then linked the claim's Health Care Common Procedure Coding System and modifier codes to work relative value units using the Medicare Physician Fee Schedule published by the Centers for Medicare & Medicaid Services (available at http://www.cms.gov/PhysicianFeeSched/PFSRVF/).

Claim-level primary care work relative value units were then summed to beneficiaries' resident PCSA level. The PCSA-level family physicians and generalists' work relative value units were then divided by the respective specialty's work relative value units per FTE derived from 2 large surveys of medical clinics[16] (4664 work relative value units per FTE for family physicians and 4554 work relative value units per FTE for general internists in 2007) to obtain specialty-specific clinical FTEs. We combined primary care FTEs of family physicians and of general internists to calculate the primary care clinical FTEs of adult primary care physicians. Age-, sex-, and race-adjusted primary care FTEs per 100 000 Medicare beneficiaries were calculated using the indirect method of adjustment. We first calculated FTEs per beneficiary of the age group, sex, and race strata for the whole population and then multiplied the rates with the number of beneficiaries in each age group, sex, and race strata within each PCSA to calculate expected FTEs. Finally, the ratio of observed to expected FTEs in each PCSA was multiplied by the national FTEs per beneficiary to derive a PCSA-level adjusted rate.[17]

Patients who are more ill use more primary care services, which might lead to a biased estimate of primary care physician FTEs. To address this, we also calculated primary care FTEs based on the last 6 months of life for chronic disease cohorts and used this in sensitivity testing. Previous studies have shown that population illness levels are poorly correlated with utilization rates across regions in the last 6 months of life.[19,20]

Statistical Analysis

Our models used patient as the unit of analysis and area-level workforce as the primary exposure variable, which allowed us to control for individual risk factors and permitted inferences to individual patients even though exposures were measured at the area level. We categorized 6542 PCSAs by quintiles of each physician workforce measure. Because of unequal numbers of beneficiaries residing in different PCSAs (interquartile range, 705-4300 beneficiaries), we sorted PCSAs in terms of increasing workforce levels, then grouped into quintiles based on study beneficiary counts such that each quintile had approximately 1 million beneficiaries. We chose quintiles rather than a continuous variable of workforce measures because of the nonlinear relationship between the exposure and the outcomes and the greater ease of interpretation of relative rates. All models were also tested with workforce measures as continuous variables and as population-weighted deciles.

For each physician workforce measure, we first examined beneficiary characteristics and outcomes by quintiles of workforce. We then developed multilevel Poisson models to examine the association between the quintiles of workforce and the 3 main outcomes.

We used individual-level covariates that could be associated with both outcomes and physician workforce (age, sex, race, the presence of any of 9 chronic conditions [cancer, congestive heart failure, chronic pulmonary disease, dementia, diabetes, peripheral vascular disease, renal failure, severe liver disease, and coronary artery disease] that are strongly associated with mortality, and the presence of multiple chronic conditions).[16,21] The presence of chronic conditions was identified from inpatient and outpatient claims based on diagnoses. We categorized race into black and nonblack, the most reliable classification available with Medicare claims.[22]

We also controlled for area covariates. Income, specialty mix, and hospital bed capacity are recognized as factors that could be associated with study outcomes and physician practice locations or patterns.[13,16,20,23,24] We used 2008 estimated zip code area median household income developed by the Primary Care Service Project (available at http://www.dartmouth.edu/~cecs/pcsa/pcsa.html) and calculated

2007 medical specialty workforce and hospital bed supply as described in previous studies.[13,16,20]

Medical specialists included allergy or immunology, cardiology, dermatology, gastroenterology, neurology, physical medicine or rehabilitation, pulmonary, geriatric medicine, nephrology, infectious disease, endocrinology, rheumatology, critical care, hematology or oncology, radiation oncology, emergency medicine, and other medical specialties. Many PCSAs have no or very few medical specialists, leading to a high degree of patient border crossing for specialty care. Therefore, instead of the 6542 PCSAs, we used 3067 hospital service areas to measure medical specialists (AMA headcounts) per total population and hospital bed supply, which were aggregations of PCSAs that reflect patient travel to inpatient care, adjusting for area patients' age and sex distribution and border crossing.[13] We did not use medical specialty workforce based on the FTEs measure derived from Medicare claims in our main model because of uncertainty of the reliability of a utilization-based definition of specialty care, but we did use the medical specialty FTEs in sensitivity testing.

All analyses were conducted using SAS version 9.2 (SAS Institute Inc, Cary, North Carolina). We used the GENMOD procedure to generate overdispersed Poisson regression models that adjust for PCSA-level clustering effects. Our final model for each outcome was adjusted for beneficiaries' age (65-69 years, 70-74 years, 75-79 years, 80-84 years, ≥85 years), sex, race (black vs nonblack), serious and multiple chronic conditions, as well as area covariates, including zip code area median household income and hospital service area medical specialist workforce. Hospital service area bed supply was included for ACSC hospitalizations and Medicare program spending models. We also performed a test of trend based on linear regression models to test for a dose-response association of physician workforce across quintile levels of measure. All statistical tests were 2-sided with statistical significance defined as $P<.05$. We recognized that in many analyses the very large sample size led to statistically significant results for small associations.

Estimated Associations of Primary Care Physician Workforce

To better understand the magnitude of the possible associations of primary care physician workforce on outcomes, we calculated the predicted deaths, ACSC hospitalizations, and Medicare program spending for all lower quintiles if all quintiles have the adjusted rates of the highest quintile. These estimates assumed that there is a causal link between workforce and outcomes, a linear association of workforce on outcomes, and evenly distributed outcomes among PCSAs within each quintile. We then summed the resulting differences in outcomes between estimates from the models and the outcomes based on the highest quintile rates across quintiles to present an overall potential benefit of the primary care physician workforce on the Medicare population.

RESULTS

Primary Care Physician Workforce Measures and Population Characteristics

A high degree of variation in adult primary care physician workforce was observed across the 6542 PCSAs, with an approximate 5-fold variation in primary care physicians per population across PCSA quintiles (median of 17.4 per 100 000 population in the lowest quintile PCSAs vs 81.3 per 100 000 population in the highest quintile PCSAs). Similarly, an almost 2-fold difference in primary care FTEs per 100 000 beneficiaries was observed between the lowest and highest quintiles (median of 64.7 per 100 000 beneficiaries in the lowest quintile PCSAs vs 103.2 per 100 000 beneficiaries in the highest quintile PCSAs) (TABLE 1). The 2 primary care workforce measures were weakly correlated (Spearman $r=0.056$; $P<.001$).

Beneficiaries' age and sex did not vary much across quintiles for either measure (Table 1). However, different directions of the level of illness burden were observed for the 2 primary care workforce measures. Beneficiaries residing in PCSAs with lower levels of physicians-to-population ratio were more likely to have had any or multiple chronic conditions, while more beneficiaries residing in PCSAs with higher levels of primary care FTEs had chronic conditions.

Primary Care Physician Workforce Measures and Study Outcomes

Unadjusted Associations. Unadjusted trends across the 2 primary care workforce measures were inconsistent (TABLE 2). For example, lower rates of ACSC hospitalizations per 1000 beneficiaries were associated with higher levels of primary care physicians per population, but with lower primary care FTEs. Opposite associations were also observed in the relationships between Medicare program spending and the 2 primary care workforce measures. Beneficiaries in areas with very high level of primary care physicians per population had lower spending, but beneficiaries in areas with more primary care FTEs had higher spending.

Adjusted Associations. After adjusting for patient and area covariates, only small differences were observed in mortality and Medicare program spending across quintiles of primary care physicians per population (TABLE 3 and TABLE 4). However, beneficiaries residing in areas with the highest quintile of primary care physicians per population had 6% lower rates of ACSC hospitalizations (relative rate [RR], 0.94; 95% confidence interval [CI], 0.93-0.95), with adjusted rates of 74.90 (95% CI, 73.57-76.27) vs 79.61 (95% CI, 78.28-80.96) per 1000 beneficiaries, respectively, for highest vs lowest quintile of primary care workforce. The test of trend of increasing quintile of workforce was not significant for any of these outcomes.

Stronger associations were observed in models that used primary care

physician FTEs as the measure of primary care workforce. For example, not only did beneficiaries residing in the highest quintile of primary care FTEs have 5% lower mortality (RR, 0.95; 95% CI, 0.93-0.96), but also 9% fewer ACSC hospitalizations (RR, 0.91; 95% CI, 0.90-0.92) and 1% higher total Medicare program spending (RR, 1.01; 95% CI, 1.004-1.02). The adjusted rates of the highest compared with lowest quintile were 5.19 (95% CI, 5.11-5.27) vs 5.49 (95% CI, 5.41-5.57) deaths per 100 beneficiaries, 72.53 (95% CI, 71.30-73.78) vs 79.48 (95% CI, 78.10-80.88) ACSC hospitalizations per 1000 beneficiaries, and $8857 (95% CI, $8710-$9003) vs $8769 (95% CI, $8617-$8920) total Medicare spending per beneficiary, respectively. There were significant trends in the association of primary care FTEs with mortality, ACSC hospitalizations, and acute care facility Medicare spending.

Estimated Primary Care Physician Workforce Absolute Associations

If all areas were assumed to have the same outcomes as the highest quintile of primary care physicians per population, and all underlying assumptions were satisfied for 100% fee-for-service Medicare beneficiaries, there would be an estimated 670 fewer deaths, 159 144 fewer ACSC hospitalizations, and $0.9 billion more in total Medicare programs spending. Similarly, if all areas' primary care FTEs increased to the highest quintile, the model suggests that this might lead to 48 398 fewer deaths and 436 002 fewer ACSC hospitalizations, but would cost $2.8 billion more in total Medicare program spending. The higher spending is from more spending in clinician spending (Part B, $7.3 billion more) that is more than the reduction from lower spending in acute care facilities (Part A, $4.5 billion less).

Primary Care Physicians vs Primary Care FTEs Workforce Measures

Given the low correlation between the 2 measures of primary care workforce, we conducted exploratory analyses with linkage of the files through the physician Unique Provider Identification Number (UPIN) to understand the possible reasons for the observed differences.

Of the 155 729 adult primary care physicians identified from the AMA Masterfile, 9494 (6%) did not have a UPIN and could not be linked to Medicare data. When UPIN was available, however, 44 618 AMA active primary

Table 1. Characteristics of 2007 20% Fee-for-Service Medicare Beneficiaries According to Quintile of Adult Primary Care Physician Workforce in PCSAs[a]

	Quintile of Primary Care Workforce (Median of Each Quintile PCSAs)					
	Primary Care Physicians per 100 000 Population[b]					
	Overall	Lowest (17.4)	2 (37.9)	3 (47.5)	4 (58.0)	Highest (81.3)
No. of beneficiaries	5 132 936	1 025 064	1 024 943	1 027 448	1 028 300	1 027 181
Age, mean (SD), y	75.6 (7.6)	75.2 (7.5)	75.5 (7.5)	75.7 (7.5)	75.8 (7.6)	76.0 (7.7)
Female sex, %	58.2	57.3	57.8	58.4	58.6	59.0
Black race, %	7.3	7.7	6.6	7.2	7.0	8.1
Chronic conditions, %[c]	37.6	37.9	38.8	38.3	37.2	35.7
Multiple chronic conditions, %[c]	11.7	12.0	12.3	12.0	11.4	10.5
Residing in urban areas, %[d]	73.1	56.3	67.4	76.2	80.6	85.0
Median household income, mean (IQR), $[e]	55 294 (43 290-63 656)	49 005 (38 793-57 141)	52 885 (42 311-61 064)	57 300 (45 416-65 984)	55 685 (44 077-62 332)	60 693 (46 427-71 468)
	Primary Care FTEs per 100 000 Beneficiaries[f]					
	Overall	Lowest (64.7)	2 (77.4)	3 (84.1)	4 (91.2)	Highest (103.2)
No. of beneficiaries	5 132 936	1 023 745	1 028 797	1 025 086	1 027 032	1 028 276
Age, mean (SD), y	75.6 (7.6)	75.8 (7.6)	75.8 (7.6)	75.6 (7.6)	75.6 (7.5)	75.4 (7.5)
Female sex, %	58.2	58.3	58.8	58.3	58.1	57.6
Black race, %	7.3	7.9	7.7	7.0	7.6	6.5
Chronic conditions, %[c]	37.6	35.1	37.1	37.6	38.1	40.0
Multiple chronic conditions, %[c]	11.7	10.3	11.4	11.6	11.8	13.2
Residing in urban areas, %[d]	73.1	63.3	77.7	77.3	77.1	70.1
Median household income, mean (IQR), $[e]	55 294 (43 290-63 656)	53 722 (41 465-61 355)	56 894 (44 945-66 044)	57 011 (44 514-64 129)	56 069 (43 470-64 905)	52 479 (42 815-59 302)

Abbreviations: FTEs, full-time equivalents; IQR, interquartile range; PCSAs, Primary Care Service Areas.
[a] *t* Tests or χ^2 tests as appropriate for characteristic differences between highest and lowest quintile were all statistically significant (all $P<.001$, except mean of median household income between highest and lowest quintile of FTEs measure, $P=.04$).
[b] Age- and sex-adjusted office-based American Medical Association Masterfile clinically active physicians per 100 000 population.
[c] Modified 9 Iezzoni chronic conditions: cancer, congestive heart failure, chronic pulmonary disease, dementia, diabetes, peripheral vascular disease, renal failure, severe liver disease, and coronary artery disease.
[d] Urban or suburban rural-urban commuting areas.
[e] Zip code area 2008 estimates from the Primary Care Service Project.
[f] Age-, sex-, and race-adjusted office-based primary care FTEs per 100 000 of study beneficiaries.

care physicians could not be classified by Medicare claims as active primary care physicians (ie, absence of general internal medicine or family medicine ambulatory claims). Of these physicians, 55% did not have any claims, suggesting that either the physician was not clinically active in 2007 or did not see fee-for-service Medicare patients or cared for very few Medicare patients. The remaining either had no ambulatory claims, their specialty was not primary care, or their patients were not within the study population.

Of the 146 649 primary care physicians identified from Medicare claims, 45 032 (31%) did not match as office-based active primary care physicians in the AMA Masterfile. Of these physicians, 4% did not link with any AMA Masterfile record, and the remaining physicians were listed by the AMA Masterfile as nonclinically active (21%), older than 65 years in 2007 (17%), or nonprimary care specialty (40%). Twelve percent of primary care physicians had primary care specialty listed in the AMA Masterfile but were self-reported as hospital-based primary care physicians.

Sensitivity of Results to Model Specification

In the sensitivity analysis, we first conducted sensitivity tests of models that used different forms of workforce measures. We substituted quintiles by continuous form (eTable 1, available at http://www.jama.com) or by deciles (eTable 2). The results did not differ from our main models.

We then conducted sensitivity tests using different selection criteria for counting AMA primary care physicians for the physicians per population measure: (1) crude physician-to-population ratios without specialty-specific patient age and sex adjustment, (2) physician-to-population ratios that included hospital-based primary care physicians, and (3) physician-to-population ratios that included residents or fellows with a 0.35 FTE clinical effort (eTable 3).[17] In none of these analyses were there meaningful differences in the results compared with our main models.

Because of the concern that primary care FTEs might be higher in areas with higher mortality risk, we also tested the possible association of the Medicare primary care FTEs with mortality, by substituting the measure with the primary care FTEs from the last 6 months of life for chronic disease cohorts (eTable 4).[25] These end-of-life primary care FTEs were correlated with our study primary care FTEs (Spearman r=0.342; $P<.001$) but not

Table 2. Unadjusted Annual Rates of Mortality, ACSC Hospitalizations, and Price-Adjusted Medicare Spending According to Quintile of Adult Primary Care Workforce in PCSAs

	Unadjusted Annual Rates (95% Confidence Interval) Quintile of Primary Care Workforce (Median of Each Quintile PCSAs)					
	Primary Care Physicians per 100 000 Population[b]					
	Lowest (17.4)	2 (37.9)	3 (47.5)	4 (58.0)	Highest (81.3)	*P* Value[a]
Mortality per 100 beneficiaries	5.42 (5.421-5.422)	5.38 (5.375-5.376)	5.33 (5.333-5.335)	5.41 (5.411-5.413)	5.36 (5.355-5.357)	.26
ACSC hospitalizations per 1000 beneficiaries	83.6 (83.583-83.585)	79.3 (79.314-79.316)	75.9 (75.941-75.943)	71.7 (71.717-71.719)	69.0 (68.970-68.972)	<.001
Medicare spending per beneficiary, $[c]						
Total	8782 (8701-8863)	8858 (8777-8938)	8735 (8654-8816)	8712 (8630-8795)	8383 (8304-8462)	<.001
Acute care facility	4768 (4703-4833)	4760 (4696-4825)	4773 (4708-4839)	4676 (4608-4743)	4627 (4563-4692)	.003
Clinician	4014 (3986-4041)	4097 (4069-4125)	3961 (3935-3988)	4037 (4009-4065)	3755 (3730-3781)	<.001
	Primary Care FTEs per 100 000 Beneficiaries[d]					
	Lowest (64.7)	2 (77.4)	3 (84.1)	4 (91.2)	Highest (103.2)	*P* Value[a]
Mortality per 100 beneficiaries	5.45 (5.447-5.448)	5.45 (5.449-5.450)	5.40 (5.401-5.403)	5.36 (5.359-5.361)	5.24 (5.239-5.241)	<.001
ACSC hospitalizations per 1000 beneficiaries	76.4 (76.443-76.444)	75.1 (75.104-75.105)	76.5 (76.469-76.470)	73.7 (73.670-73.672)	77.8 (77.812-77.814)	.02
Medicare spending per beneficiary, $[c]						
Total	8348 (8270-8425)	8547 (8468-8627)	8665 (8585-8746)	8701 (8622-8781)	9203 (9116-9291)	<.001
Acute care facility	4595 (4532-4657)	4715 (4651-4779)	4794 (4729-4859)	4690 (4627-4754)	4811 (4739-4882)	<.001
Clinician	3753 (3727-3779)	3832 (3806-3859)	3872 (3845-3898)	4011 (3984-4038)	4393 (4363-4423)	<.001

Abbreviations: ACSC, ambulatory care sensitive condition; FTEs, full-time equivalents; PCSAs, Primary Care Service Areas.
[a] *t* Test between highest and lowest quintiles.
[b] Age- and sex-adjusted office-based American Medical Association Masterfile clinically active physicians per 100 000 population.
[c] Linked to 5% 2007 Continuous Medicare History Sample (N=1 276 201); price adjustment based on Dartmouth method.
[d] Age-, sex-, and race-adjusted office-based primary care FTEs per 100 000 of study beneficiaries.

with mortality. The relative mortality rates in the model did not change significantly.

Results were similar using hospital service areas instead of PCSAs as the primary care workforce measure units (eTable 5), PCSAs categorized by unweighted quintiles (eTable 6), or using medical specialist FTEs

Table 3. Adjusted Rates of Mortality, ACSC Hospitalizations, and Price-Adjusted Medicare Spending According to Quintile of Adult Primary Care Workforce in PCSAs[a]

	Adjusted Rates (95% Confidence Interval) Quintile of Primary Care Workforce (Median of Each Quintile PCSAs)				
	Primary Care Physicians per 100 000 Population[b]				
	Lowest (17.4)	2 (37.9)	3 (47.5)	4 (58.0)	Highest (81.3)
Deaths per 100 beneficiaries	5.47 (5.39-5.54)	5.34 (5.26-5.42)	5.34 (5.26-5.42)	5.37 (5.29-5.46)	5.38 (5.30-5.47)
ACSC hospitalizations per 1000 beneficiaries	79.61 (78.28-80.96)	76.27 (74.96-77.60)	76.28 (74.95-77.64)	73.65 (72.37-74.96)	74.90 (73.57-76.27)
Medicare spending per beneficiary, $[c]					
Total	8765 (8621-8910)	8742 (8593-8890)	8682 (8530-8834)	8872 (8721-9024)	8722 (8566-8878)
Acute care facility	4851 (4729-4973)	4785 (4660-4909)	4843 (4715-4971)	4870 (4742-4997)	4942 (4810-5073)
Clinician	3914 (3866-3962)	3957 (3907-4007)	3839 (3788-3890)	4003 (3952-4053)	3781 (3729-3833)
	Primary Care FTEs per 100 000 Beneficiaries[d]				
	Lowest (64.7)	2 (77.4)	3 (84.1)	4 (91.2)	Highest (103.2)
Deaths per 100 beneficiaries	5.49 (5.41-5.57)	5.46 (5.37-5.54)	5.40 (5.32-5.48)	5.37 (5.29-5.45)	5.19 (5.11-5.27)
ACSC hospitalizations per 1000 beneficiaries	79.48 (78.10-80.88)	76.85 (75.52-78.22)	76.78 (75.44-78.14)	73.99 (72.73-75.28)	72.53 (71.30-73.78)
Medicare spending per beneficiary, $[c]					
Total	8769 (8617-8920)	8673 (8522-8824)	8728 (8576-8880)	8721 (8573-8869)	8857 (8710-9003)
Acute care facility	4991 (4864-5119)	4912 (4785-5040)	4940 (4812-5068)	4824 (4700-4949)	4696 (4573-4820)
Clinician	3777 (3727-3828)	3761 (3710-3811)	3789 (3738-3839)	3897 (3848-3946)	4160 (4112-4209)

Abbreviations: ACSC, ambulatory care sensitive condition; FTEs, full-time equivalents; PCSAs, Primary Care Service Areas.
[a] Data are adjusted for individual age, sex, race, chronic conditions, zip code area median household income, hospital service area specialty workforce, and hospital service area bed supply for hospitalizations and spending.
[b] Age- and sex-adjusted office-based American Medical Association Masterfile clinically active physicians per 100 000 population.
[c] Linked to 5% 2007 Continuous Medicare History Sample (N=1 276 201); price adjustment based on Dartmouth method.
[d] Age-, sex-, and race-adjusted office-based primary care FTEs per 100 000 of study beneficiaries.

Table 4. Adjusted Relative Rates of Mortality, ACSC Hospitalizations, and Price-Adjusted Medicare Spending According to Quintile of Adult Primary Care Workforce in PCSAs[a]

	Adjusted Relative Rates (95% Confidence Interval) Quintile of Primary Care Workforce (Median of Each Quintile PCSAs)					
	Primary Care Physicians per 100 000 Population[b]					
	Lowest (17.4)	2 (37.9)	3 (47.5)	4 (58.0)	Highest (81.3)	*P* for Trend
Mortality	1.00 [reference]	0.98 (0.97-0.99)	0.98 (0.96-0.99)	0.98 (0.97-0.99)	0.98 (0.97-1.00)	.49
ACSC hospitalizations	1.00 [reference]	0.96 (0.95-0.97)	0.96 (0.95-0.97)	0.93 (0.92-0.93)	0.94 (0.93-0.95)	.06
Medicare spending per beneficiary[c]						
Total	1.00 [reference]	1.00 (0.99-1.00)	0.99 (0.98-1.00)	1.01 (1.01-1.02)	1.00 (0.99-1.00)	.87
Acute care facility	1.00 [reference]	0.98 (0.98-0.99)	1.00 (0.99-1.01)	1.00 (0.99-1.01)	1.02 (1.01-1.03)	.15
Clinician	1.00 [reference]	1.01 (1.00-1.02)	0.98 (0.98-0.99)	1.02 (1.02-1.03)	0.97 (0.96-0.97)	.51
	Primary Care FTEs per 100 000 Beneficiaries[d]					
	Lowest (64.7)	2 (77.4)	3 (84.1)	4 (91.2)	Highest (103.2)	*P* for Trend
Mortality	1.00 [reference]	0.99 (0.98-1.01)	0.98 (0.97-1.00)	0.98 (0.97-0.99)	0.95 (0.93-0.96)	.02
ACSC hospitalizations	1.00 [reference]	0.97 (0.96-0.98)	0.97 (0.96-0.98)	0.93 (0.92-0.94)	0.91 (0.90-0.92)	.005
Medicare spending per beneficiary[c]						
Total	1.00 [reference]	0.99 (0.98-1.00)	0.99 (0.99-1.00)	0.99 (0.99-1.00)	1.01 (1.00-1.02)	.37
Acute care facility	1.00 [reference]	0.98 (0.97-0.99)	0.99 (0.98-1.00)	0.96 (0.95-0.97)	0.94 (0.93-0.95)	.02
Clinician	1.00 [reference]	1.00 (0.99-1.00)	1.00 (1.00-1.01)	1.03 (1.03-1.04)	1.10 (1.09-1.10)	.07

Abbreviations: ACSC, ambulatory care sensitive condition; FTEs, full-time equivalents; PCSAs, Primary Care Service Areas.
[a] Data are adjusted for individual age, sex, race, chronic conditions, zip code area median household income, hospital service area specialty workforce, and hospital service area bed supply for hospitalizations and spending. *P* values are test of trend by linear regression models.
[b] Age- and sex-adjusted office-based American Medical Association Masterfile clinically active physicians per 100 000 population.
[c] Linked to 5% 2007 Continuous Medicare History Sample (N=1 276 201); price adjustment based on Dartmouth method.
[d] Age-, sex-, and race-adjusted office-based primary care FTEs per 100 000 of study beneficiaries.

(eTable 7) in the models. In addition, we also confirmed that our findings were consistent after adjusting for urban vs rural settings (eTable 8) and for 3 individual ACSC hospitalizations (eTable 9).

COMMENT

Using the most commonly-used national measure of primary care physician workforce, we found that Medicare beneficiaries residing in areas with the highest level of adult primary care physicians per population had modestly lower mortality and fewer ACSC hospitalizations, but did not observe a consistent stepwise association (ie, improved outcomes were not associated linearly with increasing primary care physicians per population). Stronger associations were observed for mortality, ACSC hospitalization, and Medicare spending when the measure of the primary care workforce reflected the workforce of primary care physician ambulatory care clinical effort (primary care FTEs per beneficiary).

Our findings suggest that a higher local workforce of primary care physicians has a generally positive benefit for Medicare populations, but that this association may not simply be the result of having more physicians trained in primary care in an area. Instead, associations were much stronger with a measure of primary care activity that was linked to a central concept of primary care—ambulatory care delivered in an office or clinic setting by physicians trained in primary care. The FTEs measure also more accurately reflected physician retirement or part-time effort.

Our findings are consistent with previous research that a higher primary care physician workforce as measured with AMA Masterfile data are associated with lower mortality and ASCS hospitalization rates.[4,5,9,26] However, we found that the associations of primary care physician workforce on spending were mixed. Although there was relatively higher overall spending, a higher level of primary care FTEs was associated with lower acute care facility Medicare spending. One possible explanation is that some hallmarks of primary care, such as early detection, prevention, and coordination of care, might reduce hospital use but result in a tradeoff of greater clinician spending.

The stronger associations between Medicare primary care FTEs per 100 000 beneficiaries with lower mortality and ACSC hospitalizations compared with primary care physicians per 10 000 population suggests that the benefits of the primary care workforce are from the amount of ambulatory clinical care provided, rather than the number of primary care physicians locally available. Although the associations of both workforce measures with mortality and ACSC hospitalization were in the same direction, the associations with Medicare spending were dissimilar. One possible explanation, supported by our matching of AMA Masterfile physicians with claims, is that the AMA Masterfile misclassifies some specialist physicians, such as hospitalists and emergency department physicians, as general internists and family physicians. In this case, higher primary care physicians per population could be a marker for greater hospital capacity that is associated with acute care spending. Although the study did not separate clinician spending in acute care facilities from outpatient sites, the inverse relationship between acute care facility and clinician spending observed for both primary care workforce measures may represent a substitution of higher spending for physician services in outpatient care for lower hospitalization and hospital-based physician services.

Our study points to the weak connection of the numbers of those physicians trained in primary care, and often counted as primary care physicians for planning and research, with those physicians actually delivering ambulatory primary care services. This suggests that having a higher number of primary care physicians in an area does not always lead to having more primary care services, such as more office visits provided to Medicare beneficiaries. In addition, in some areas, there is a relatively high number of primary care FTEs without particularly high primary care physicians as traditionally measured.

Many of the physicians who would be classified as providing primary care by the AMA Masterfile were either not providing care to fee-for-service Medicare beneficiaries or were providing nonambulatory or specialty care. Similarly, a significant proportion of the physicians delivering primary care services as per Medicare were not classified as office-based primary care physicians in the AMA Masterfile. If the measurement of primary care physicians is intended to represent the concept of primary care practice, research and health care planning that relies solely on the AMA Masterfile for primary care physician counts will not accurately measure the primary care workforce.

Our analyses address important weaknesses of previous studies.[5,9,10] Instead of an ecological study design with workforce exposure, covariates, and outcomes measured at an area level, we used hierarchical models with beneficiaries as the units of analysis to measure the associations between area-level workforce exposure and patient-level outcomes. Patient-level adjustment included age, sex, race, and illness level. Adjustment for community income was at the lowest practical level, the zip code area. We also included area-level adjustment for medical specialty physicians and hospital bed supply. Our study used relatively small service areas (PCSAs) that reflect the actual geographic markets of Medicare office-based primary care.

Because of concerns that the AMA Masterfile may not adequately reflect the actual practice roles of physicians, we also used clinical primary care FTEs derived from the 100% Medicare claims for a 20% sample of beneficiaries as a secondary measure of primary care physician workforce. Although primary care activity might be correlated with outcomes (ie,

patients who are more ill use more care), similar findings observed when end-of-life primary care FTEs (uncorrelated with mortality) was used in sensitivity analyses. The possibility of the findings representing reverse causality, in which patients who are more ill are preferentially cared for by specialists rather than primary care physicians, is unlikely given the greater comorbidity of patients in the highest primary care FTE quintile.

Several limitations in our study deserve discussion. First, this study of fee-for-service Medicare beneficiaries cannot be generalized to younger populations or beneficiaries enrolled in risk-bearing health maintenance organization plans, such as Medicare Advantage. Our study population, however, is of national importance as the US population continues to age with most Medicare program services reimbursed on a fee-for-service basis. Second, our measures of primary care physician workforce, similar to many other studies of primary care, did not include data about advanced practice nurses and physician assistants. Third, although the use of individual level data improves upon many previous studies,[6,7] it did not ensure perfect risk adjustment. Fourth, our cross-sectional analysis did not capture one of the core attributes of primary care—longitudinal care for an extended period. Our study, however, was not intended to measure the value of specific aspects of primary care practice, but the benefits of a greater number of physicians engaged in ambulatory primary care practice. Federal and state health policy makers have placed great importance on the workforce size of this specific group of physicians by allocating resources for additional graduate medical education training and practice incentives.[2,27,28]

Current policy proposals to strengthen primary care in the US health care delivery system have been directed toward 2 objectives. The first policy objective is to reinvigorate the role of primary care in the coordination of care, particularly for patients with chronic illness. The patient-centered medical home is one example of the enhanced role of primary care clinicians.[29,30] The second policy objective is to increase the training of primary care clinicians, with the expectation that higher numbers of clinicians will lead to patients receiving more effective primary care.[26,31]

These 2 objectives are interrelated. Patient-centered medical homes and accountable care organizations[32] cannot function without an adequate level of primary care clinicians. At present, medical student preferences are strongly directed toward subspecialties and family medicine programs are in decline,[33] providing early warning signs of future serious shortages that could seriously impede health care reform efforts.

Our study offers the cautionary note that having more physicians trained in primary care practicing in an area, by itself, does not ensure substantially lower mortality, fewer hospitalizations, or lower costs. The benefits of primary care workforce appear quite sensitive to the accurate discrimination of those physicians trained in primary care with those practicing ambulatory primary care. Recognizing this difference is important not just to improve primary care clinician measurement, but also as an indication of the drift of physicians trained as primary care physicians to nonprimary care careers. Increasing the training capacity of family medicine and internal medicine may have disappointing patient benefits if the resulting physicians are primary care in name only.

Author Contributions: Dr Chang had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Chang, Stukel, Flood, Goodman.
Acquisition of data: Goodman.
Analysis and interpretation of data: Chang, Stukel, Flood, Goodman.
Drafting of the manuscript: Chang, Goodman.
Critical revision of the manuscript for important intellectual content: Chang, Stukel, Flood, Goodman.
Statistical analysis: Chang, Stukel, Goodman.
Obtained funding: Goodman.
Administrative, technical, or material support: Goodman.
Study supervision: Flood.

Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Dr Goodman reported speaking fees from Texas Medical Association; Health Action Council, Cincinnati; Richard Stockton College of New Jersey; Iowa Health Business Alliance; Alliance for Academic Internal Medicine; American Medical Association; Connecticut Children's Hospital; Mt Sinai Hospital, New York; World Congress; Rutgers University; Baystate Medical Center; Brigham and Women's Hospital; ESRI Inc; Illinois Hospital Association; National Hospice Workgroup; National Association of Health Data Organizations; St. Peters University Hospital, New Brunswick, New Jersey; Massachusetts Hospital Association; Cooper Health System, Camden, New Jersey; Organizzato dal Laboratorio Management e Sanità Scuola Superiore Sant'Anna di Pisa; Kentucky Academy of Family Physicians; Southern Illinois University Health Policy Institute; Ohio University College of Osteopathic Medicine; Institute for Clinical Quality and Value; The Marwood Group; American Society of Clinical Oncologists; OR Manager; Delta Health Alliance; SUNY Upstate University; and Intermountain Healthcare; and consulting fees from Vermont Department of Banking, Insurance, Securities and Health Care Administration; HealthDialog; Colorado Foundation for Medical Care; Seyferth Blumenthal and Harris; and American Medical Forensic Specialists. Drs Chang, Stukel, and Flood reported no disclosures.
Funding/Support: This research was supported in part by the Robert Wood Johnson Foundation and grant P01 AG19783 from the National Institute on Aging.
Role of the Sponsors: The Robert Wood Johnson Foundation and the National Institute on Aging had no role in the design and conduct of the study, in the collection, management, analysis, and interpretation of the data, or in the preparation, review, or approval of the manuscript.
Online-Only Material: eTables 1 through 9 are available at http://www.jama.com.

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Those who think they have not time for bodily exercise will sooner or later have to find time for illness.

—Edward Stanley (1826-1893)