DOI: 10.1111/j.1475-6773.2005.00403.x

More May Be Better: Evidence of a Negative Relationship between Physician Supply and Hospitalization for Ambulatory Care Sensitive Conditions

James N. Laditka, Sarah B. Laditka, and Janice C. Probst

Objective. To conduct an empirical test of the relationship between physician supply and hospitalization for ambulatory care sensitive conditions (ACSH).
Data Sources/Study Setting. A data set of county ACSH rates compiled by the Safety Net Monitoring Initiative of the Agency for Healthcare Research and Quality (AHRQ). The analytical data set consists of 642 urban counties and 306 rural counties. We supplemented the AHRQ data with data from the Area Resource File and the Environmental Protection Agency.
Study Design. Ordinary least squares regression estimated ACSH predictors. Physician supply, the independent variable of interest in this analysis, was measured as a continuous variable (MDs/100,000). Urban and rural areas were modeled separately. Separate models were estimated for ages 0–17, 18–39, and 40–64.
Data Extraction Methods. Data were limited to 20 states having more than 50 percent of counties with nonmissing data.
Principal Findings. In the urban models for ages 0–17, standardized estimates indicate that, among the measured covariates in our model, physician supply has the largest negative adjusted relationship with ACSH ($p<.0001$). For ages 18–39 and 40–64, physician supply has the second largest negative adjusted relationship with ACSH ($p<.0001$, both age groups). Physician supply was not associated with ACSH in rural areas.
Conclusions. Physician supply is positively associated with the overall performance of the primary health care system in a large sample of urban counties of the United States.
Key Words. Physician supply, ambulatory care sensitive conditions, primary care access

Hospitalization for ambulatory care sensitive conditions (ACSH), also called potentially preventable hospitalization, is a commonly used indicator of the accessibility and overall effectiveness of primary health care (Weissman, Gatsonis, and Epstein 1992; Billings et al. 1993; Institute of Medicine 1993; Bindman et al. 1995; Pappas et al. 1997; Laditka 2003; Laditka, Laditka, and Mastanduno 2003). A major premise of the indicator is that better access to primary health care should reduce hospitalizations for the conditions it represents. The supply of primary care physicians is a notable component of access. Individuals in areas with low supply may have more difficulty accessing primary care than do individuals in areas with greater supply, as evidenced by longer waiting times for appointments, longer travel times to obtain care, shorter physician encounters, and reduced follow-up (Zastowny, Roghmann, and Cafferata 1989).

Access barriers are common in center-city areas with low proportions of fully insured persons, and in rural areas, where low population makes it difficult to support practitioners. Congress created the Health Professional Shortage Area (HPSA) designation in the late 1970s in recognition of these barriers. To be designated as a HPSA, an area must have a population to full-time-equivalent (FTE) primary care physician ratio of at least 3,500 to 1, or a population to FTE primary care physician ratio of less than 3,500 to 1 but greater than 3,000 to 1 and insufficient capacity of existing primary care providers. HPSA communities are eligible for practitioners from the National Health Services Corps (Criteria for Designation of Health Manpower Shortage Areas 1980). There are currently 1,347 designated primary care HPSAs in U.S. metropolitan areas, and 2,672 in nonmetropolitan areas (Bureau of Health Professions 2004). About 20 percent of the U.S. population resides in primary medical care HPSAs (Bureau of Health Professions 2004). There are also 4,195 officially designated Medically Underserved Areas, which similarly have greater needs for health practitioners, as defined by an index comprised of physician supply, infant mortality, percentage of population with incomes below the poverty level, and percentage of the population age 65 or over (Bureau of Health Professions 2004). Thus, many areas of the United States are designated as having low physician supply.

Address correspondence to James N. Laditka, D.A., Ph.D., Research Assistant Professor, Department of Epidemiology and Biostatistics, Arnold School of Public Health, University of South Carolina, 800 Sumter Street, Columbia, SC 29208. Dr. Laditka is also Director of Research, Office for the Study of Aging, Center for Health Services Policy and Research at the University of South Carolina. Sarah B. Laditka, Ph.D., is Associate Professor and MHA Program Director, Department of Health Services Policy and Management, Arnold School of Public Health, University of South Carolina, Columbia, SC. Janice C. Probst, Ph.D., is Associate Professor and Director, South Carolina Rural Health Research Center, Department of Health Services Policy and Management, Arnold School of Public Health, University of South Carolina, Columbia, SC.

Better knowledge of relationships between physician supply and access can usefully inform policy. Yet, surprisingly few studies examine these relationships. We extend research in this area by investigating the association between physician supply and ACSH, using data representing most counties of 20 U.S. states. Our expectation is that physician supply will be negatively associated with ACSH. We also extend ACSH research by controlling for characteristics that may be associated with ACSH, such as air quality and disease prevalence.

BACKGROUND

The ACSH indicator has contributed usefully to knowledge about the accessibility and overall performance of primary health care (Weissman, Gatsonis, and Epstein 1992; Billings et al. 1993; Bindman et al. 1995; Pappas et al. 1997; Laditka 2003; Laditka, Laditka, and Mastanduno 2003). The indicator informs federal health policy, and that of many states (e.g., Schreiber and Zielinski 1997; Ricketts et al. 2001). Asthma, diabetes, chronic obstructive pulmonary disease (COPD), and congestive heart failure (CHF) exemplify chronic ambulatory care sensitive conditions (ACSCs). Pharmaceuticals and patient education from primary care physicians can reduce, although not eliminate, hospitalization for these conditions. Bacterial pneumonia and urinary tract infections exemplify acute ACSCs. Unless they progress to serious complications, such conditions are in most cases easily treated with antibiotics without hospitalization. Thus, a higher rate of ACSH in an area suggests the possibility of lower accessibility or quality in the area's primary health care system.

Only five studies have examined the relationship between physician supply and ACSH. Four of these studies used continuous physician supply measures, with conflicting results. Two found no association (Krakauer et al. 1996; Ricketts et al. 2001), one a positive association (Schreiber and Zielinski 1997), and the fourth the expected negative association (Parchman and Culler 1994). A fifth study examined effects of quartile measures of physician supply using data representative of U.S. urban areas, finding that older individuals residing in areas with low supply had higher ACSH risk, and that those in areas having what might be termed "adequate supply" had significantly lower risk (Laditka 2004). Higher ACSH rates have also been found for Medicare beneficiaries residing in rural areas or core standard metropolitan statistical areas (Culler, Parchman, and Przybylski 1998). Komaromy et al. (1996) found that, although physician practice style varied across areas, this variation did not account for variation in hospital admission rates for several ACSCs. Variation across areas may also stem from patient preferences about health care use, or from differing disease rates or severity (Komaromy et al. 1996).

Drawing on ACSH theory and the empirical results just described, we test the hypothesis that higher levels of primary care physician supply will be associated with lower ACSH rates. We model the risks for rural and urban counties separately, as rural and urban areas differ in demographic characteristics, environment, economic conditions, insurance coverage, and social structure (Eberhardt, Ingram, and Makuc 2001), and have different primary care access barriers (Coburn 2002). Research has shown notable ACSH risk variation among age groups (Laditka and Johnston 1999; Laditka, Laditka, and Mastanduno 2003). Thus, we estimated separate models for children (0–17), younger adults (18–39), and middle age adults (40–64).

METHODS

Population and Data Sources

Our principal data source was a set of county ACSH rates from the Safety Net Monitoring Initiative of the Agency for Healthcare Research and Quality (AHRQ) (Billings and Weinick 2003b). The rates were compiled primarily from the 1999 Nationwide Inpatient Sample (NIS), part of the Health Care Cost and Utilization Project, and represent counties of 29 states and the District of Columbia. Rates were not reported for counties with small populations, or for those with no hospital. To minimize bias, we restricted our analysis to 20 states with data for more than 50 percent of each state's counties. Our analytical data set has 642 urban counties, and 306 rural counties. Rural was defined using the rural indicator variable supplied with the AHRQ data. This definition includes small cities of 20,000 or more, not adjacent to metropolitan areas, and areas with less population. States included in our analysis are shown in Table 1. The table shows the proportion of each state's counties that were useable for the analysis, and the proportion of the full sample constituted by the state's useable counties. Included states represent major sections of the Northeast and mid-Atlantic regions, and the West coast. We supplemented the AHRQ data with data from the Area Resource File (ARF) and the Environmental Protection Agency (EPA).

Dependent Variable

We used county ACSH rates. The AHRQ rates were not adjusted for county race or ethnicity characteristics, or for other factors. We adjusted for such

Table 1: Proportion of Counties with Useable Data from Each State, and Percentage Contribution from Each State to the Full Analytic Sample*

State	*Proportion of Counties Used from Each State*	*Percent of Full Sample*	*State*	*Proportion of Counties Used from Each State*	*Percent of Full Sample*
Arizona	0.87	1.91	North Carolina	0.73	10.56
California	0.84	7.18	New Jersey	1.00	3.08
Connecticut	1.00	1.17	New York	0.97	8.80
Florida	0.73	6.89	Oregon	0.56	3.08
Hawaii	1.00	0.59	Pennsylvania	0.90	8.80
Illinois	0.52	7.77	Rhode Island	1.00	0.73
Massachusetts	0.86	1.76	South Carolina	0.76	5.28
Maryland	0.92	3.23	Tennessee	0.58	8.06
Maine	0.94	2.20	Washington	0.67	3.96
Minnesota	0.69	8.50	Wisconsin	0.60	6.45

**Source: Monitoring the Health Care Safety Net. Book II: A Data Book for States and Counties* (Billings and Weinick, 2003b); data from a given state were used only when the proportion of counties with useable data within the state exceeded 0.5; States in the Safety Net Monitoring Initiative data that were omitted from our analysis were predominantly rural states: Arkansas, Colorado, Georgia, Iowa, Kansas, Missouri, Nevada, Utah, and Virginia; Washington, DC, was also among the omitted areas.

factors in the regressions. Diagnoses identifying ACSHs closely follow those published elsewhere (Institute of Medicine 1993; Laditka 2003; Billings and Weinick 2003a). ACSCs included are specific diagnoses for angina, asthma, bacterial pneumonia, cellulitis (excluding most surgical procedures), convulsions, COPD, CHF, diabetes, gastroenteritis, hypertension, hypoglycemia, severe ear/nose/throat infections, and several combinations of skin grafts with cellulitis and specific procedure codes.

Conceptual Model and Variable Coding

Our models are based on a theory of health services need and use at the level of county populations. We assume that need and use are functions of each county's health system characteristics, demographic characteristics, social and economic characteristics, environmental quality, and population health. Table 2 lists all variables and their data sources. All variables in the analysis are measured at the county level.

Health System and Use Characteristics. These measures control for area characteristics that may influence primary care access and hospitalization

Table 2: Data Sources for Analysis of Hospitalization for Ambulatory Care Sensitive Conditions*

Variable	*Data Sources*
Number primary care MDs/100,000	MDs, 1999 data from 2001 ARF; population is 1999 interpolated estimate from 2001 Claritas data*
Short-term general hospital beds per 1,000	1999 American Hospital Association Annual Survey; Claritas*
Percent of hospitals investor owned	2002 ARF, from U.S. Census 2000
Medicaid generosity	Centers for Medicare and Medicaid Services—HCFA-2082 Reports; denominator: 1999–2001 Current Population Survey, 3-year average*
Community health center in county	Health Resources and Services Administration, Uniform Data System*
Emergency department visits per 1,000	Numerator 1999 American Hospital Association Annual Survey; denominator Claritas (Note: based on physician location, not patient origin)
Percent African American, Hispanic, Asian, and Native American	U.S. Census 2000*
Percent < high school graduation	2002 ARF, from U.S. Census 2000
Percent age 16+ unemployed	U.S. Census 2000*
Crime rate per 10,000	Numerator Federal Bureau of Investigations Uniform Crime Reports; denominator Claritas*
Persons per square mile	Numerator U. S. Census 2000; denominator Claritas*
Percent of: population change, 1990–2000; families headed by single parents; households with income < $15K or > $75K	U.S. Census 2000*
Percent ages 5–20/21–64 with disability	U.S. Census 2000*
Percent annual days with unhealthy air	U.S. Environmental Protection Agency AQS Database. Percent of days when air quality either "unhealthy for sensitive groups" (AQI, 101–150) or "unhealthy, very unhealthy, or hazardous" (AQI ≥ 151). EPA calculates AQI from five major air pollutants: ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide.
Death rates: heart disease, COPD, diabetes, liver disease	1997–1999, 3-Year Averages, National Center for Health Statistics, from 2002 ARF

*The original data source is given in the table; in instances associated with this footnote, we obtained the data not from the original, but from: *Monitoring the Health Care Safety Net. Book II: A Data Book for States and Counties* (Billings and Weinick, 2003b); all variables are measured at the county level.

MD, doctors of medicine; ARF, Area Resource File; AQS, Air Quality System; AQI, Air Quality Index; COPD, chronic obstructive pulmonary disease.

risks independent of the aggregated risks of individuals. Hospital bed supply is often correlated with physician supply. However, it is generally expected that the risk of hospitalization will rise throughout the range of bed supply (Fisher et al. 1994). Physician supply, on the other hand, should generally be negatively associated with ACSH. Physician supply was measured as a continuous variable, representing primary care physicians in office-based practice per 100,000 populations. The primary care physician category includes nonfederal doctors of medicine (MDs) and doctors of osteopathy (DOs) providing direct patient care, who practice principally in general or family practice, general internal medicine, or pediatrics. Physicians engaged solely in administration, research, and teaching were excluded. Physicians may be in solo practice, group practice, two-physician practice, or other patient care employment. It should be noted that the office-based practice category does not include physicians employed under contract with hospitals to provide direct patient care if they are not also engaged in office-based practice. In some areas, physicians in hospital-based practice provide considerable primary care. However, available data on physicians in hospital-based practice do not permit researchers to distinguish physicians who are primarily engaged in outpatient care in clinics or emergency departments (EDs) from the much larger number of hospital-based physicians who provide direct patient care for admitted patients. Thus, the office-based category provides the best available measure of primary care physician supply.

Medicaid expenditures per person under age 65 whose income is below 200 percent of the poverty threshold are included to control for public support for health care for poorer people. We label this covariate "Medicaid generosity." It is not a measure of total county Medicaid expenditures. All things being equal, counties with more wealth or higher income can afford greater Medicaid generosity. Medicaid generosity may also be related to political cultures and social environments. Thus, we do not expect that this measure should be notably correlated with measures of income. Greater support levels should be associated with lower ACSH risk. Areas with community health centers should have improved access to care, and lower ACSH risk (Garg et al. 2003). Programs to improve the accessibility and quality of primary care have notably reduced ED visits (Hurley, Freund, and Taylor 1989; Grossman, Rich, and Johnson 1998; Zuckerman, Brennan, and Yemane 2002). Results of such programs suggest that areas with high levels of ED visits may have less access to primary care, and therefore poorer population health. Thus, greater ED use should be associated with higher

ACSH rates. Investor ownership provides incentives to promote hospital occupancy, and should increase ACSH.

Demographic Characteristics. Demographic characteristics of county populations are associated with both health needs and propensity to use health care. We controlled for factors associated with race and ethnicity by including separate covariates for the percentage of each county's residents identifying themselves as African-American, Hispanic, Native-American, or Asian. Much evidence suggests that African Americans are less likely than many other groups to receive appropriate medications and education about management of chronic diseases (Institute of Medicine 2002). Previous ACSH research has generally found that African Americans have higher ACSH risks (Schreiber and Zielinski 1997; Culler, Parchman, and Przybylski 1998; Ricketts et al. 2001; Garg et al. 2003; Laditka 2003; Laditka, Laditka, and Mastanduno 2003). Culture and language pose additional barriers for Hispanics and other American minorities (Collins et al. 2002). These factors may often make it difficult for minorities to establish trusting relationships with primary care providers, and to benefit fully from treatment. Hispanics, however, may have notably lower hospitalization rates despite less access to care. This is often referred to as the "Hispanic paradox." Thus, the proportion of an area's population that is Hispanic may be negatively associated with ACSH. Population density may be associated with health care need and use (Schreiber and Zielinski 1997).

Social and Economic Characteristics. Social and economic characteristics include the ability of county populations to obtain primary care, comply with prescribed regimens, and influence physician discretion. Less education is associated with less health knowledge and less knowledge of the health care system. Thus, counties with higher percentages of residents that did not graduate from high school should have higher ACSH risk. Unemployment is likely to be associated with delays in medical care seeking, and higher ACSH risk. Income levels, both low and high, may also affect health care needs and use. A greater percentage of households with incomes less than \$15,000 should increase ACSH (Billings et al. 1993). However, ACSH may also to some extent measure preferences for health care, manifest at higher income levels in increased hospitalization. Individuals with higher incomes are also more likely to be insured; there is evidence that the insured are more likely to be hospitalized for ACSCs (Oster and Bindman 2003). Thus, the proportion of residents with incomes above \$75,000 may be positively associated with

ACSH. More families headed by single parents should increase ACSH risks, as single parent households are associated with lower income, less health insurance, and generally more difficulty accessing health care or complying with physicians' recommendations. Recent population growth should be associated with reduced ACSH risk, as population growth is generally associated with increasing economic opportunity. The relationship between crime rates and physical exercise is unclear (Burdette and Whitaker 2004; Wilson et al. 2004). However, perceptions of crime risk significantly reduce exercise behavior, and thus may be associated with poorer health (Eyler et al. 2003) and greater ACSH risk. We use crime rates to control for this factor.

Population Health Factors. Population health factors are associated with health, disability, and disease. Areas with higher mortality and morbidity rates are likely to have greater health needs, which should be associated with higher ACSH risk. Controls for health need have been modeled in the ACSH literature only occasionally (Culler, Parchman, and Przybylski 1998; Laditka, Laditka, and Mastanduno 2003; Laditka 2003, 2004), although their usefulness has been recognized (Schreiber and Zielinski 1997). Heart disease, COPD, and diabetes are chronic conditions that contribute notably to ACSH. We incorporate death rates for these diseases to adjust for county disease prevalence and severity. Higher death rates from these diseases should be associated with higher ACSH risk. While liver disease is not an ACSC, liver disease mortality provides a control for rates of heavy alcohol consumption (Parrish and Dufour 1991; Ramstedt 2001, 2003). Death rates for these diseases may also indicate health care access barriers; areas that do not provide adequate access to necessary medical care may experience higher death rates. Thus, including these death rates may over-adjust ACSH rates. Our approach is likely to provide both more conservative estimates of the effect of physician supply on ACSH and a useful degree of control for disease prevalence and severity. To examine the impact of these controls in the two adult models (where these covariates were relevant), we also estimated the models with these covariates omitted. Additionally, individuals with disabilities have greater access barriers than do those without them (Culler, Parchman, and Przybylski 1998). We therefore included a control for the percentage of the county population with a disability.

Environmental Quality. Environmental quality affects population health. Areas with more days of unhealthy air should have higher rates of ACSH, as poor air quality is associated with increased hospitalization risk for several

ACSCs, including asthma, CHF, and COPD (Künzli et al. 2003). Air quality data is not available for all counties, particularly those in rural areas. Air quality was missing for 78 percent of rural counties, and is not included in the rural models. Because air quality is generally less of a problem in rural areas, we do not believe this omission affects our results notably. Air quality information was missing for 32 percent of the urban counties. We addressed these missing values by imputing air quality in the following manner. Separately for each state, we calculated the mean percentage of annual days of poor air quality for counties at each level of the Rural–Urban Continuum Code (RUCC) in the ARF. For counties missing air quality data, we assigned the mean value from counties in the same state having the same RUCC value. This reduced the number of observations with missing air quality values by 45 percent. Remaining counties were in states that did not have other urban counties with both the same RUCC value and nonmissing air quality measures. We assigned air quality values to these counties using the mean percentage of annual days of poor air quality across all urban counties with the same RUCC value.

Statistical Analysis

We estimated ACSH risk using multivariate ordinary least squares (OLS) regression. We present standardized coefficients, to examine the relative influence of the model covariates as contributors to ACSH. To examine whether the air quality imputation notably influenced the models, we also estimated them with this covariate omitted. Results were not notably affected by the omission.

RESULTS

Descriptive Analysis

Descriptive statistics for variables in the urban model are shown in Table 3. About 10.57 percent of hospitalizations in the 0–17 age category were ACSH, 7.11 percent at ages 18–34, and 20.45 percent at ages 40–64. The mean percentage of African-American county residents was 10.04 percent. Hispanics were 6.82 percent.

The mean number of primary care physicians in office-based practice for every 100,000 persons was about 56 (SD 34.1) in rural counties, and about 27 percent larger in urban counties, at 71 (SD 40.2) (table not shown). The number of primary care physicians per 100,000 in rural counties ranged from 4.1 to

Table 3: Means and Standard Deviations of Variables Used in the Models Predicting Rate of ACSH in Urban Areas, Year 2000*

	Mean (SD)
Outcome variables	
ACSH rate, ages 0–17	10.57 (6.023)
ACSH rate, ages 18–39	7.11 (3.016)
ACSH rate, ages 40–64	20.45 (8.540)
Health system and use factors	
Number of primary care MDs per 100,000	71.12 (40.192)
Short-term general hospital beds per 1,000	2.75 (2.000)
Percent of hospitals investor owned	9.10 (23.132)
Medicaid generosity†	1.31 (0.299)
Community health center in county	0.43 (0.496)
Emergency department visits per 1,000	381.51 (177.013)
Demographic factors	
Percent identifying self as African-American	10.04 (12.537)
Percent identifying self as Hispanic	6.82 (9.158)
Percent identifying self as Asian	2.23 (3.906)
Percent identifying self as Native-American	0.89 (4.082)
Percent $<$ high school graduation	18.45 (6.471)
Percent age 16+ unemployed	5.52 (2.168)
Crime rate per 10,000 (/1,000)	0.37 (0.132)
Persons per square mile/1,000	0.91 (3.623)
Social and economic factors	
Percent population change, 1990–2000	16.51 (18.086)
Percent of families headed by single parents	27.40 (6.779)
Percent of households with income $<$ \$15K	15.16 (5.273)
Percent of households with income $>$ \$75K	21.08 (9.295)
Population health factors	
Percent of population age 5–20 with a disability	8.09 (1.253)
Percent of population age 21–64 with a disability	18.70 (4.192)
Percent of days annual days with unhealthy air	3.18 (3.709)
Death rate, heart disease ($\times$ 100)	0.17 (0.063)
Death rate, COPD ($\times$ 100)	0.04 (0.015)
Death rate, diabetes ($\times$ 100)	0.02 (0.008)
Death rate, liver disease ($\times$ 100)	0.01 (0.004)

**Source: Monitoring the Health Care Safety Net. Book II: A Data Book for States and Counties* (Billings and Weinick, 2003b); urban *n* used for models = 642; all variables are measured at the county level.

†Medicaid expenditures per person under age 65 below 200% of the poverty threshold (divided by 1,000).

SD, standard deviation; COPD, chronic obstructive pulmonary disease; ACSH, hospitalization for ambulatory care sensitive conditions; MD, doctors of medicine.

158.1, with a coefficient of variation of 42.8. The number in urban counties ranged from 9.8 to 438.6, with a coefficient of variation of 56.5. Rural/urban differences in our data set are less than they would be in data representing all

U.S. counties, as very rural counties and those lacking a hospital were not included. To provide perspective on the "true" range of rural/urban differences, we examined physician supply for excluded rural counties in the studied states, using the ARF. Physician supply per 100,000 ranged from 0 to 34.7 in these areas, with a mean of 7.9 (SD = 6.0), and coefficient of variation 76.5.

Multivariate Analysis

Results of multivariate OLS regression models of ACSH risk for three age groups in urban areas are reported in Table 4. Variance tolerance tests (i.e., "auxiliary regressions") were performed for all models (Gujarati 1988); there was little evidence of notable multicollinearity (not shown). To further examine the possibility that multicollinearity might challenge the estimations, the models were estimated with data from which observations were randomly deleted (Griffiths, Hill, and Judge 1993). The estimates from these models did not differ meaningfully from those presented, suggesting that multicollinearity does not affect our results. Coefficients presented in the table are standardized coefficients (i.e., β coefficients). These coefficients measure the change in the dependent variable, measured in standard deviations (SDs), that results from a one-SD change in the independent variable.

Greater physician supply was associated with lower ACSH rates in all age groups. For children, physician supply was the largest contributor to ACSH rate reduction ($b = -0.239$, $p < .0001$). Increasing physician supply by one SD (40.2 per 100,000), holding all other variables in the model constant, reduces the ACSH rate by 0.239 SDs; the SD of the ACSH rate for children is 6.023 (see Table 3). Thus, increasing physician supply by one SD reduces the mean ACSH rate for this age group by about 13.6 percent (calculations performed as: $6.023 \times 0.239 = 1.439$; 10.570, the mean ACSH rate for ages 0–17, minus $1.439 = 9.131$; $9.131/10.570 = 0.864$; $1 - 0.864 = 0.136$). For the adult results, we focus on models that include controls for disease prevalence and severity. In the model for younger adults, physician supply was the second most influential contributor to ACSH risk reduction ($b = -0.164$, $p < .0001$), following the percent of county residents identifying themselves as Hispanic ($b = -0.168$, $p < .001$). In the model for ages 40–64, physician supply was again the second most influential contributor to ACSH risk reduction ($b = -0.196$, $p < .0001$), following the percent of county residents identifying themselves as Hispanic ($b = -0.278$, $p < .0001$). The estimates for ages 18–39 and 40–64 represent reductions of the mean ACSH rates associated with a one SD increase in physician supply of 7.0 and 8.2 percent, respectively.

Table 4: OLS Regression Predicting Rates of Hospitalization for Ambulatory Care Sensitive Conditions in Urban Counties, by Age†

	Models without Disease Controls			*Models with Disease Controls*	
	Ages 0–17 b‡	*Ages 18–39 b*	*Ages 40–64 b*	*Ages 18–39 b*	*Ages 40–64 b*
Health system factors					
MDs per 100,000	– 0.239***	– 0.186***	– 0.204***	– 0.164***	– 0.196***
Hospital beds per 1,000	0.245***	0.279***	0.201***	0.227***	0.183***
% for-profit hospitals	0.052	0.075+	0.070*	0.083**	0.072*
Medicaid generosity§	– 0.060	– 0.080*	– 0.068*	– 0.066+	– 0.064+
CHC in county	0.029	0.046	0.037	0.044	0.037
ED visits/1,000	0.082+	0.037	0.049	0.059	0.056
Demographic factors					
% African American	0.111+	0.051	0.133*	0.113+	0.157*
% Hispanic	– 0.016	– 0.230***	– 0.299***	– 0.168**	– 0.278***
% Asian	– 0.015	– 0.023	– 0.017	0.005	– 0.008
% Native American	– 0.084+	– 0.120***	– 0.159***	– 0.086*	– 0.145***
% < high school	0.293***	0.422***	0.404***	0.377***	0.390***
% age 16+ unemployed	– 0.139+	– 0.042	0.086	– 0.046	0.086
Crime rate per 10,000¶	0.065	0.076+	0.011	0.082+	0.014
Persons/square mile¶	0.157***	0.110***	0.062+	0.085*	0.054
Social, economic factors					
Population change‖	– 0.107*	– 0.063	– 0.094*	0.004	– 0.073+
% single parent families	– 0.006	0.118	0.095	0.112	0.092
% households < $15K	0.177+	0.001	0.113	– 0.033	0.103
% households > $75K	0.142	0.251***	0.253***	0.213**	0.242***
Health factors					
% with a disability	– 0.028	0.205***	0.187***	0.149+	0.169*
% days unhealthy air	– 0.003	0.001	0.039	0.002	0.040
Death rate, heart disease	NA	NA	NA	0.175**	0.062
Death rate, COPD	NA	NA	NA	– 0.050	– 0.008
Death rate, diabetes	NA	NA	NA	0.107*	0.024
Death rate, liver disease	NA	NA	NA	– 0.037	– 0.017
R^2	0.30	0.51	0.62	0.53	0.62

† *Source: Monitoring the Health Care Safety Net. Book II: A Data Book for States and Counties* (Billings and Weinick, 2003b); urban *n* used for models = 642; because the disease measures were primarily for adults, disease controls were not included in the model for ages 0–17.

‡ *b*, standardized coefficient.

§ Medicaid expenditures per person under age 65 below 200 percent of the poverty threshold (divided by 1,000).

¶ Entered in the model divided by 1,000.

‖ Percent population change, 1990–2000.

+ $p<.05$;

* $p<.01$;

** $p<.001$;

*** $p<.0001$.

CHC, community health center; ED, emergency department; COPD, chronic obstructive pulmonary disease, death rates entered in the model × 100; NA, not applicable.

Estimates for control covariates generally conform to expected results. Lower education levels in a county are associated with greater ACSH risks, as is a greater supply of hospital beds. In the adult models, greater income is also associated with greater ACSH risk, a result that may be associated with preferences for health care. An unexpected result in our findings is the negative association between the percentage of county residents identifying themselves as Native American and ACSH. We expected that Native Americans would have greater ACSH risks, based on greater disease burdens and lifestyle challenges. The unexpected result may be because of the fact that these models focus on residents of urban counties, where risks for Native Americans may differ from those affecting their rural counterparts. In the rural models (table not shown), on the other hand, the covariate representing Native Americans was positively signed in all age groups, of notable magnitude, and marginally statistically significant for ages 18–39 ($p = .0787$).

The two adult models estimated without the controls for disease prevalence and severity are also shown in Table 4. These models produced a modestly greater effect of physician supply on ACSH rate reduction (both $p < .0001$), compared with the models that included disease controls.

In the analogous models of ACSH risk for rural counties (table not shown), there was no evidence that physician supply was associated with ACSH. To examine whether these results may have been affected by the definition of rural areas, we also estimated models with an expanded rural definition from the ARF: counties with populations of 20,000 or more, adjacent to metropolitan areas, and counties with less population. This alternative did not affect the results.

DISCUSSION

Across most urban counties of 20 states, the supply of primary care physicians was negatively associated with ACSH. These results are consistent with two previous analyses (Parchman and Culler 1994; Laditka 2004). Considered together, other related studies have produced mixed results (Krakauer et al. 1996; Schreiber and Zielinski 1997; Ricketts et al. 2001). Krakauer et al. (1996) studied Medicare beneficiaries, whereas our analysis examined children and younger adults. Ricketts et al. (2001) combined rural and urban areas. Schreiber and Zielinski (1997) examined only New York State. Thus, these studies differed notably from ours; it should not be expected that their results and ours would agree. Few previous ACSH studies have included the ecological controls we used. These controlled for demographic characteristics, qualities of local health systems and measures of health care use, socioeconomic characteristics, and measures of population health and air quality. The inclusion of these controls may account in part for some of the differences in findings between our results and those of previous studies.

Two factors may account for the lack of significant findings for rural counties. The number of rural counties in our sample was notably smaller than the number of urban counties, while the range of physician supply was considerably smaller in rural counties than in urban counties. Both factors reduce power to detect differences. It is also possible that the relationship between physician supply and ACSH differs between rural and urban areas (Schreiber and Zielinski 1997).

Several considerations are relevant to interpreting our findings. Our results cannot be extended to very rural counties, or to counties without a hospital. Our results also cannot be generalized to all states. It should be noted that these county rates were not based on individuals' counties of residence. To the extent that individuals represented in the rates resided in the counties in which the hospitals were located, or in counties that shared the characteristics of the hospital counties, the results should provide a useful indication of physician supply effects. County borders do not necessarily represent health service areas, although for some populations, such as Medicaid beneficiaries, county policies may often affect the availability of health care. Moreover, physician supply and other measures in our models can vary notably across small areas within counties. Such variation may introduce measurement error into our analysis. It would be desirable to include controls for ACSH risk factors, such as smoking and exercise, and for the prevalence of other chronic ACSCs, such as asthma. Such data are not available for counties.

In both adult models, counties with higher percentages of households with incomes greater than \$75,000 had higher ACSH rates, controlling for all other factors in the model. Laditka et al. (2003) observed that some ACSCs are subject to notable variation in hospitalization rates across areas. These include angina, asthma, cellulitis, diabetes, COPD, gastroenteritis, hypertension, kidney and urinary tract infections, and pneumonia. For high-variation conditions, the clinical rationale for hospitalization may be ambiguous at moderate levels of disease severity. Further, there is evidence that the consumption of medical care, including hospitalization, may be greater in areas with more income (Feldstein 1999). Individuals with high income are also well positioned to influence physicians in the hospitalization decision. Physicians may hospitalize individuals with high income at lower thresholds of disease severity for high-variation conditions, in response to either patient preferences or economic incentives. Thus, the positive association between ACSH and high income may indicate preferences for health care among individuals with higher income, or physician admitting practices for these individuals. Our models do not include controls for county health insurance profiles. It is likely that the measures for income and education account for this factor to a considerable degree.

Our approach assumed that the primary care system may not be able to overcome all area health challenges. We therefore controlled for death rates for several diseases that notably contribute to ACSH. To the extent that these covariates measure disease rates and disease severity, they provide a control for county health burdens. A portion of the effect of these controls may be attributable to lack of access to health care, because areas with low access may have higher death rates. Thus, our models may over-adjust ACSH. We examined the sensitivity of the models to the exclusion of these controls. With these controls omitted, the effect size of physician supply on ACSH increased modestly. In addition to a measure of physician supply, future ACSH research might incorporate an assessment of physician training or specialty certification, by linking physicians with the Physician Masterfile of the American Medical Association.

Our findings suggest that, at least for urban areas, primary care physician supply may positively affect the overall performance of the primary health care system. This information can contribute to the ongoing debate on physician supply and distribution (Blumenthal 2004). Across the past 20 years, increases in the overall number of physicians in the United States have not markedly reduced regional disparities in physician/population ratios (Goodman 2004). Despite federal and state efforts to direct potential physicians toward primary care, growth in the number of primary care physicians has been minimal (Goodman 2004). Economic incentives for physicians are unlikely to resolve regional disparities, as areas with low or worsening practitioner availability over time tend to have both greater health care needs and fewer economic resources (Luo, Wang, and Douglass 2004).

While policy efforts may not have altered the distribution of physicians (Goodman 2004), state and federal practitioner obligation programs do provide physicians for underserved areas and populations (Pathman et al. 2004). These programs may be associated with both retention in underserved areas (Pathman et al. 2004) and continued service to low income populations (Probst et al. 2003). Thus, policies promoting practitioner placement in underserved areas, such as the National Health Service Corps, state loan repayment programs, and Title VII training programs will continue to be needed to provide a health care safety net. Our findings suggest that greater physician supply positively affects the overall performance of the primary health care system.

References

Billings, J., and R. M. Weinick. 2003a. *Monitoring the Health Care Safety Net, Book I: A Data Book for Metropolitan Areas, AHRQ Publication No. 03-0025.* Rockville, MD: Agency for Healthcare Research and Quality.

———. 2003b. *Monitoring the Health Care Saftey Net, Book II: A Data Book for States and Counties, AHRQ publication No. 03-0026.* Rockville, MD: Agency for Healthcare Research and Quality.

Billings, J., L. Zeitel, J. Lukomnik, T. S. Carey, A. E. Blank, and L. Newman. 1993. "Impact of Socioeconomic Status on Hospital Resource Use in New York City." *Health Affairs* 12 (1): 162–73.

Bindman, A. B., K. Grumbach, D. Osmond, M. Komaromy, K. Vranizan, N. Lurie, J. Billings, and A. Stewart. 1995. "Preventable Hospitalization and Access to Health Care." *Journal of the American Medical Association* 274 (4): 305–11.

Blumenthal, D. 2004. "New Steam from an Old Cauldron—the Physician-Supply Debate." *New England Journal of Medicine* 350 (17): 1780–7.

Burdette, H. L., and R. C. Whitaker. 2004. "Neighborhood Playgrounds, Fast Food Restaurants, and Crime: Relationships to Overweight in Low-Income Preschool Children." *Preventive Medicine* 38 (1): 57–63.

Bureau of Health Professions. "Bureau of Health Professions, Health Resources and Services Administration" [accessed February 13, 2004]. Available at http://bhpr.hrsa.gov/shortage/. Rockville, MD: U.S. Department of Health and Human Services.

Coburn, A. F. 2002. "Rural Long-Term Care: What Do We Need to Know to Improve Policy and Programs?" *Journal of Rural Health* 18: 256–69.

Collins, K. S., D. L. Hughes, M. M. Doty, B. L. Ives, J. N. Edwards, and K. Tenney. 2002. "Diverse Communities, Common Concerns: Assessing Health Care Quality for Minority Americans: Findings from the Commonwealth Fund 2001 Health Care Quality Survey. The Commonwealth Fund" [accessed October 10, 2004]. Available at www.cmwf.org.

"Criteria for Designation of Health Manpower Shortage Areas." 1980. Federal Register 45, pp. 75996–6010.

Culler, S. D., M. L. Parchman, and M. Pryzbylski. 1998. "Factors Related to Potentially Preventable Hospitalizations among the Elderly." *Medical Care* 36 (6): 804–17.

Eberhardt, M., D. Ingram, and D. Makuc. 2001. *Urban and Rural Health Chartbook. Health, United States, 2001.* Hyattsville, MD: National Center for Health Statistics.

Eyler, A. A., D. Matson-Koffman, D. R. Young, S. Wilcox, J. Wilbur, J. L. Thompson, B. Sanderson, and K. R. Evenson. 2003. "Quantitative Study of Correlates of Physical Activity in Women from Diverse Racial/Ethnic Groups: The Women's

Cardiovascular Health Network Project—Summary and Conclusions." *American Journal of Preventive Medicine* 25 (3, Suppl. 1): 93–103.

Feldstein, P. J. 1999. *Health Care Economics.* 5th edition. Albany, NY: Delmar Publishers.

Fisher, E. S., J. E. Wennberg, T. A. Stuck, and S. M. Sharp. 1994. "Hospital Readmission Rates for Cohorts of Medicare Beneficiaries in Boston and New England." *New England Journal of Medicine* 331 (15): 1017–8.

Garg, A., J. C. Probst, T. Sease, and S. E. Samuels. 2003. "Potentially Preventable Care: Ambulatory Care-Sensitive Pediatric Hospitalizations in South Carolina in 1998." *Southern Medical Journal* 96: 850–58.

Goodman, D. C. 2004. "Twenty-Year Trends in Regional Variations in the U.S. Physician Workforce" [accessed October 18, 2004]. *Health Affairs* 23: W90–W97 (Web publication available at http://www.healthaffairs.org)

Griffiths, W. E., R. C. Hill, and G. G. Judge. 1993. *Learning and Practicing Econometrics.* New York: John Wiley and Sons Inc.

Grossman, L. K., L. N. Rich, and C. Johnson. 1998. "Decreasing Nonurgent Emergency Department Utilization by Medicaid Children." *Pediatrics* 102: 20–4.

Gujarati, D. N. 1988. *Basic Econometrics.* New York: McGraw-Hill.

Hurley, R. E., D. A. Freund, and D. E. Taylor. 1989. "Emergency Room Use and Primary Care Case Management: Evidence from Four Medicaid Demonstration Programs." *American Journal of Public Health* 79 (7): 843–6.

Institute of Medicine. 2002. *Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care*, edited by B. D. Smedley, A. Y. Stith, and A. R. Nelson. Washington, DC: National Academy Press.

———. 1993. *Access to Health Care in America*, edited by M. Millman. Washington, DC: National Academy Press.

Komaromy, M., N. Lurie, D. Osmond, K. Vranizan, D. Keane, and A. B. Bindman. 1996. "Physician Practice Style and Rates of Hospitalization for Chronic Medical Conditions." *Medical Care* 34 (6): 594–609.

Krakauer, H., I. Jacoby, M. Millman, and J. E. Lukomnik. 1996. "Physician Impact on Hospital Admission and on Mortality Rates in the Medicare Population." *Health Services Research* 31 (2): 191–211.

Künzli, N., R. McConnell, D. Bates, T. Bastain, A. Hricko, F. Lurmann, E. Avol, F. Gilliland, and J. Peters. 2003. "Breathless in Los Angeles: The Exhausting Search for Clean Air." *American Journal of Public Health* 93 (9): 1494–9.

Laditka, J. N. 2003. "Hazards of Hospitalization for Ambulatory Care Sensitive Conditions among Older Women: Evidence of Greater Risks for African Americans and Hispanics." *Medical Care Research and Review* 60 (4): 468–95.

———. 2004. "Physician Supply, Physician Diversity, and Outcomes of Primary Health Care for Older Persons in the United States." *Health and Place* 10: 231–44.

Laditka, J. N., S. B. Laditka, and M. P. Mastanduno. 2003. "Hospital Utilization for Ambulatory Care Sensitive Conditions: Health Outcome Disparities Associated with Race and Ethnicity." *Social Science and Medicine* 57: 1429–41.

Laditka, S. B., and J. M. Johnston. 1999. "Preventable Hospitalization and Avoidable Maternity Outcomes: Implications for Access to Health Services for Medicaid Recipients." *Journal of Health and Social Policy* 11 (2): 41–56.

Luo, W., F. Wang, and C. Douglass. 2004. "Temporal Changes of Access to Primary Health Care in Illinois (1990–2000) and Policy Implications." *Journal of Medical Systems* 28 (3): 287–99.

Oster, A., and A. B. Bindman. 2003. "Emergency Department Visits for Ambulatory Care Sensitive Conditions: Insights into Preventable Hospitalizations." *Medical Care* 41 (2): 198–207.

Pappas, G., W. C. Hadden, L. J. Kozak, and G. F. Fisher. 1997. "Potentially Avoidable Hospitalizations: Inequalities in Rates between US Socioeconomic Groups." *American Journal of Public Health* 87 (5): 811–6.

Parchman, L., and S. Culler. 1994. "Primary Care Physicians and Avoidable Hospitalizations." *Journal of Family Practice* 39 (2): 123–9.

Parrish, K. M., and M. C. Dufour. 1991. "Drinking Patterns and Liver Cirrhosis Mortality." *Alcohol and Alcoholism* 1 (Suppl.): 331–4.

Pathman, D. E., T. R. Konrad, T. S. King, D. H. Taylor Jr. and G. G. Koch. 2004. "Outcomes of States' Scholarship, Loan Repayment, and Related Programs for Physicians." *Medical Care* 42 (6): 560–8.

Probst, J. C., M. E. Samuels, T. V. Shaw, L. G. Hart, and C. Daly. 2003. "The National Health Service Corps and Medicaid Inpatient Care: Experience in a Southern State." *Southern Medical Journal* 96 (8): 775–83.

Ramstedt, M. 2001. "Per Capita Alcohol Consumption and Liver Cirrhosis Mortality in 14 European Countries." *Addiction* 96 (Suppl. 1): S19–33.

———. 2003. "Alcohol Consumption and Liver Cirrhosis Mortality with and without Mention of Alcohol—The Case of Canada." *Addiction* 98 (9): 1267–76.

Ricketts, T. C., R. Randoph, H. A. Howard, D. Pathman, and T. Carey. 2001. "Hospitalization Rates as Indicators of Access to Primary Care." *Health and Place* 7: 27–38.

Schreiber, S., and T. Zielinski. 1997. "The Meaning of Ambulatory Care Sensitive Admissions: Urban and Rural Perspectives." *Journal of Rural Health* 13 (4): 276–84.

Weissman, J. S., C. Gatsonis, and A. M. Epstein. 1992. "Rates of Avoidable Hospitalization by Insurance Status in Massachusetts and Maryland." *Journal of the American Medical Association* 268 (17): 2388–94.

Wilson, D. K., K. A. Kirtland, B. E. Ainsworth, and C. L. Addy. 2004. "Socioeconomic Status and Perceptions of Access and Safety for Physical Activity." *Annals of Behavioral Medicine* 28 (1): 20–8.

Zastowny, T. R., J. K. Roghmann, and G. L. Cafferata. 1989. "Patient Satisfaction and the Use of Health Services: Explorations in Causality." *Medical Care* 27: 705–23.

Zuckerman, S., N. Brennan, and A. Yemane. 2002. "Has Medicaid Managed Care Affected Beneficiary Access and Use?" *Inquiry* 39 (3): 221–42.