Associations Among Hospital Capacity, Utilization, and Mortality of U.S. Medicare Beneficiaries, Controlling for Sociodemographic Factors

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Objective. To explore whether geographic variations in Medicare hospital utilization rates are due to differences in local hospital capacity, after controlling for socioeconomic status and disease burden, and to determine whether greater hospital capacity is associated with lower Medicare mortality rates.

Data Sources/Study Setting. The study population: a 20 percent sample of 1989 Medicare enrollees. Measures of resources were based on a national small area analysis of 313 Hospital Referral Regions (HRR). Demographic and socioeconomic data were obtained from the 1990 U.S. Census. Measures of local disease burden were developed using Medicare claims files.

Study Design. The study was a cross-sectional analysis of the relationship between per capita measures of hospital resources in each region and hospital utilization and mortality rates among Medicare enrollees. Regression techniques were used to control for differences in sociodemographic characteristics and disease burden across areas.

Data Collection/Extraction Methods. Data on the study population were obtained from Medicare enrollment (Denominator File) and hospital claims files (MedPAR) and U.S. Census files.

Principal Findings. The per capita supply of hospital beds varied by more than twofold across U.S. regions. Residents of areas with more beds were up to 30 percent more likely to be hospitalized, controlling for ecologic measures of socioeconomic characteristics and disease burden. A greater proportion of the population was hospitalized at least once during the year in areas with more beds; death was also more likely to take place in an inpatient setting. All effects were consistent across racial and income groups. Residence in areas with greater levels of hospital resources was not associated with a decreased risk of death.

Conclusions. Residence in areas of greater hospital capacity is associated with substantially increased use of the hospital, even after controlling for socioeconomic characteristics and illness burden. This increased use provides no detectable mortality benefit.

Key Words. Hospital bed supply, hospitalization, mortality, Medicare

For the past 50 years, researchers have documented marked geographic variations in the amount of hospital care received by Americans (Chassin, Brook, and Park 1986; Connell, Day, and LoGerfo 1981; Krakauer et al. 1996; Lembcke 1952; Lewis 1969; Wennberg and Gittelsohn 1973). And the costs associated with greater use of the hospital are substantial: per capita spending on acute hospital care in 1993 was only $914 in Seattle, Washington and $851 in New Haven, Connecticut, but was $1,475 in Chicago, Illinois and $1,202 in Boston, Massachusetts (Wennberg 1996).

The underlying cause of these variations, however, has been the subject of debate. Some researchers have emphasized the role of local hospital capacity (Wennberg, Freeman, and Culp 1987; Wennberg and Gittelsohn 1973), while others have stressed the importance of differences in socioeconomic and health status (Billings, Zeitel, Lukomnik, et al. 1993; Hofer, Wolfe, Tedeschi, et al. 1998); a few have argued that local bed supply has no influence on utilization (Bindman, Grumbach, Osmond, et al. 1995). The importance of the debate lies in the policy implications of the alternative hypotheses. If differences in utilization are due to different levels of need, then the variations observed in hospital utilization are not a cause for concern. However, if hospital capacity and utilization relative to underlying need do vary across communities, then the possibility arises to achieve substantial cost savings without harming health.

In this study, we address two questions: first, whether the differences in utilization experienced by Medicare populations living in areas with a greater

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per capita bed supply are due to differences in population characteristics (such as income or disease burden); and second, whether, after controlling for these population characteristics, those who live in areas of greater bed supply have a detectable benefit in terms of lower mortality rates.

METHODS

Study Population

The study population was a 20 percent sample of Medicare enrollees age 65 and over who were eligible for Medicare Part A (hospital insurance) during calendar year 1989 (mortality analyses) or 1990 (utilization analyses) identified from the Medicare enrollment ("Denominator") file (Mitchell, Bubolz, Paul, et al. 1994). In this age group, Medicare provides coverage to over 95 percent of the U.S. population (Fisher, Baron, Malenka, et al. 1990). We excluded members of risk-bearing health maintenance organizations (4.0 percent of eligible enrollees) because their discharge records were incomplete, and those residing in zip codes for which no census data were available (0.5 percent of eligible enrollees). The final study population was 5.53 million (representing 27.6 million Medicare enrollees).

MEASURES

Dependent Variables. Discharges were ascertained using Medicare Part A hospital discharge files ("MedPAR" file) (Mitchell, Bubolz, Paul, et al. 1994). We used the enrollment file to ascertain all deaths during 1989 for the study population.

Population Characteristics. Individual level data were available for age, race, and gender from the Medicare Denominator File. Because Medicare's files include only four racial designations (white–87.5 percent, black–7.4 percent, other–2.0 percent, and unknown–3.1 percent), we collapsed these categories to black and non-black (which includes unknown). Data from the 1990 U.S. Census, measured at the level of the postal zip code, were used to estimate individuals' living arrangements (rural, suburban, urban), education, income, marital, and employment status (for the entire resident population); median household income and poverty status (age 65 and over); and three measures of disability (also for the population over age 65): those with limitations in self-care needs, limitations in mobility, and work disability. We also used the hospital discharge file to control for differences across

Hospital Service Areas (HSAs) in illness rates. We selected specific events for which hospitalization is a proxy for the incidence of disease and not a reflection of greater hospital capacity (Fisher et al. 1994; Wennberg, Freeman, and Culp 1987; Wennberg, McPherson, and Caper 1984): hospitalizations for hip fracture, cancer of the colon or lung treated surgically, acute myocardial infarction, and stroke. The age-, sex-, and race-adjusted HSA level incidence rates for these conditions were used as an additional measure of disease burden.

Definition of Hospital Service Areas and Hospital Referral Regions. These were defined as previously described (Wennberg 1996; Wennberg and Gittelsohn 1973). Briefly, 1989 hospital discharges for Medicare enrollees 65 and older were used to assign each zip code to the hospital of predominant use, with the additional requirement of geographic contiguity. In metropolitan areas, hospitals with overlapping service areas were grouped into single HSAs. These individual HSAs were then aggregated into 313 Hospital Referral Regions (HRRs) based on travel patterns for cardiothoracic and neurologic surgery.

Measures of Hospital Resources (Table 1). Our primary measure of the amount of hospital resources available to the Medicare population was the in-area bed supply, a simple tally of the number of staffed hospital beds in hospitals within the HRR divided by the resident population in 1990. This is the most appropriate measure for analyses that examine the associations between bed availability and utilization. We also employed this measure for our analyses of mortality. The per capita supply of in-area beds, however, has serious limitations as a measure of resource inputs for the Medicare population, failing to account for variations in occupancy rates, border crossing, and the share of local hospital resources received by the population under age 65. Any absence of an association between greater inputs and improved mortality could simply reflect imprecision in this measure. We therefore repeated the mortality analyses using two additional measures: (1) the age-sex-race–adjusted inpatient day rate in the HRR, a direct measure of the hospital resources provided to the Medicare population in the inpatient setting; and (2) the inpatient day rate in the six months prior to death among those who died (calculated using deaths that occurred in 1994, to avoid including any deaths among the current study population). The patient day rate will be confounded by local illness rates (and will be interpretable as a measure of resource inputs only if adequate adjustment across areas in Medicare beneficiaries' risk of death is achieved). The inpatient day rate in the last six months of life, however, should be unconfounded by area level illness rates, as the population in whom the patient day rate is measured will be similarly ill (in terms of their risk of death) across geographic areas.

Physicians. We also controlled for the local per capita supply of clinically active physicians in each HSA based on data obtained from the American Medical Association and the American Osteopathic Association for 1993.

Regression Analyses

Unit of Analysis. For the regression models examining mortality, the unit of analysis was the individual Medicare enrollee. For the models examining discharges, the unit of analysis was the five-year age-sex-race and zip code stratum, since we did not distinguish among multiple hospitalizations to the same person. Individual level data were available for age, race, gender, and mortality. Other covariates were measured at the zip code, HSA, or HRR level.

Regression Models. To estimate the relationship between in-area bed supply and hospital discharge rates (e.g., Figure 1), we used Poisson regression (McCullagh and Nelder 1983), weighting by the number of subjects

Table 1: Measures of Hospital Resources Used in the Analyses

Measure (Units)	*How Defined*	*Comment*
In-area beds (beds per 1000)	The number of staffed acute care hospital beds within the region, divided by the resident general population. Mean: 3.6 Range: 1.1–6.6	Measures local availability of beds. Poor measure of hospital resources for the Medicare population because of variations in occupancy rates, border crossing, and the share of hospital care received by the non-Medicare population.
Inpatient day rate (days per capita)	The number of inpatient days per year experienced by the Medicare population divided by the resident Medicare population (age, sex, race adjusted). Mean: 2.8 Range: 1.4–4.6	Most direct measure of the level of hospital resources provided to the Medicare population. Differences in use across regions, however, will be highly confounded by local illness rates.
Inpatient day rate in last six months of life (days per capita)	The number of inpatient days experienced by Medicare enrollees in their last six months of life (age, sex, race adjusted). Mean: 11.2 Range: 4.4–22.9	Measures the propensity to use the hospital independent of local illness rates, because the persons used to calculate the measure are likely to be similarly ill across areas: all are destined to die in the next six months.

in each age-sex-race and zip code stratum, controlling for all demographic, socioeconomic, and health status variables described earlier. To estimate the relationship between the three measures of hospital resources and Medicare mortality, we used logistic regression (Hosmer and Lemeshow 1989), controlling for the same demographic, socioeconomic, and health status variables. For computational efficiency, we used strata based on five-year age groups, race, sex, and zip code, weighting each stratum by its number of Medicare enrollees. The dependent variable was the stratum-specific 1989 mortality rate. The models are available from the authors. Point estimates and confidence intervals for the odds ratios and rate ratios were obtained by transforming the corresponding regression parameters in the usual fashion. We incorporated variance over-dispersion in the estimates of all standard errors to account for any clustering of deaths or hospitalizations within strata, as well as for multiple hospitalizations to the same patient (Donner and Donald 1987).

We conducted separate regressions for blacks and non-blacks and for two income strata among non-blacks. The models for blacks excluded HSAs with fewer than 500 black Medicare enrollees. Low-income groups were defined as those living in zip codes where white median family income was less than $14,000, approximately 23 percent of the non-black Medicare population. We also repeated the regressions in strata based on the size of the HSA, in HSAs with teaching hospitals, and in HSAs with Medicare HMO penetration of 3 percent or less. Similar results were obtained. All tests were performed at the 5 percent level of significance and were two-sided.

RESULTS

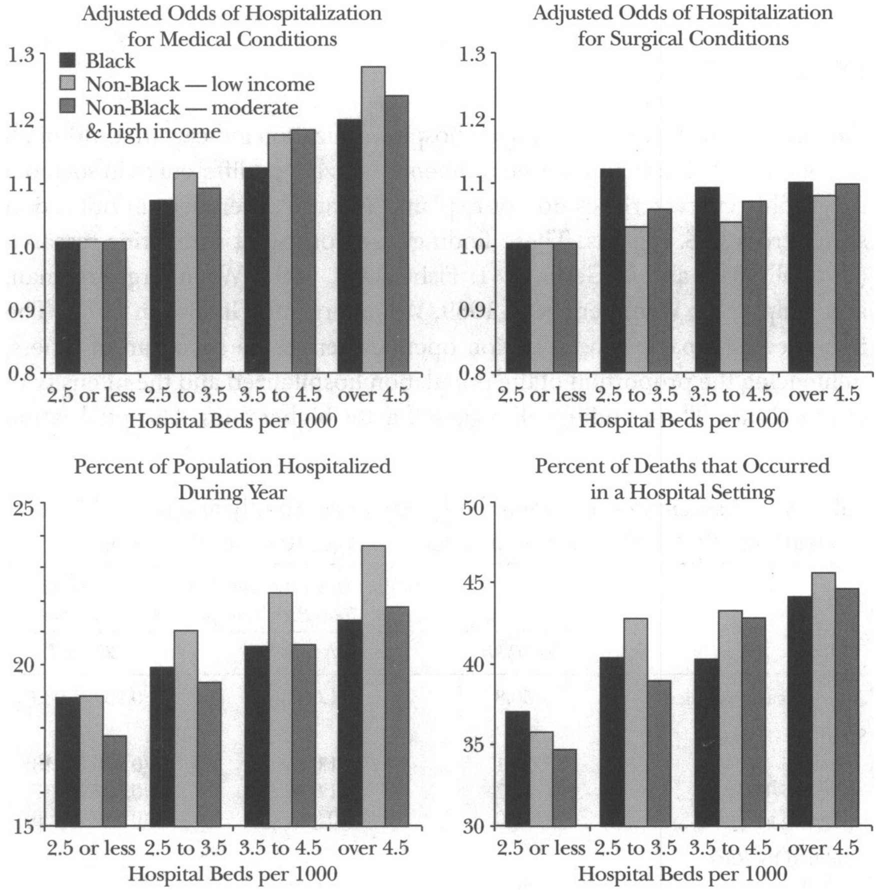
Association Between Hospital Bed Supply and Hospital Utilization

Residence in areas with greater per capita numbers of hospital beds is associated with higher hospitalization rates, predominantly for medical (nonsurgical) causes of admission (Figure 1). Medicare enrollees living in areas with more beds are more likely to be admitted to the hospital at least once during the year. Among those who die, death is more likely to occur in the hospital in areas with a greater supply of beds. Although differences in utilization are apparent across income and racial groups, the association between increased capacity and utilization is found in each income and race group.

Associations Between Hospital Resources and Mortality

The associations between in-area hospital beds and mortality were weak and mostly non-significant at conventional levels of statistical significance

Figure 1: Relationship Between In-Area Bed Supply and Medicare Hospital Use



Notes: Odds ratios for comparisons of medical and surgical hospitalization rates across HRRs are derived from the logistic regression model, controlling for age, race, and sex (individual level variables); income, education, disability, urban/rural location (zip code level variables); illness rates (HSA level variables); and region of the country. The percentage of the Medicare population hospitalized in a given year and the percentage of Medicare deaths that occur in-hospital were calculated as age-sex-race–adjusted rates using indirect adjustment.

(Table 2). In no subgroup of the population was a significant mortality benefit from increased local bed availability detected. We repeated these analyses using the other measures of hospital resource inputs and again found no benefit from increased inputs overall (Table 3) or in any age, race, or income subgroup of the population (data not shown). Regardless of the dependent variable used in the analysis, no mortality benefit from increased hospital bed availability or propensity to use the hospital was found.

DISCUSSION

Our analyses of Medicare enrollees' hospital utilization indicate that, although sociodemographic characteristics influence utilization, differences in sociodemographic characteristics do not explain the large differences in utilization seen across U.S. regions. These findings are consistent with prior research (Connell, Day, and LoGerfo 1981; Fisher et al. 1994; Wennberg, Freeman, and Culp 1987; Wennberg et al. 1989; Wennberg and Gittelsohn 1973). The influence of capacity on utilization operates across the spectrum of illness, influencing the proportion of the population hospitalized and the intensity of terminal care. These findings all suggest that the higher rates of hospitalization

Table 2: Associations Between the In-Area Bed Supply and the Odds of Death in 1989 for Medicare Enrollees by Age, Race, and Income

	*Mortality Rate (Per 1000)**	*Odds of Death Associated with Increase of One Bed per 1000 Population for Medicare Enrollees*	
		odds ratio†	*95% CI*
All Medicare Enrollees	50.8	1.003	(0.997, 1.009)
Stratified by Age			
Age 65–74	27.1	1.007	(0.996, 1.018)
Age 75–84	61.2	1.007	(0.997, 1.017)
Age 85 and over	148.0	0.994	(0.982, 1.006)
Stratified by Race			
Black‡	56.7	1.009	(0.987, 1.031)
Non-Black	50.3	1.002	(0.996, 1.009)
Stratified by Income§			
Low income	52.0	0.987	(0.974, 1.001)
Middle and high income	50.5	1.008	(1.000, 1.015)

*Crude mortality rate (per 1000) for all Medicare enrollees over age 65 and not enrolled in risk-based HMO.

†Odds ratio for linear trend derived from logistic regression model, controlling for age, race, and sex (individual level variables); income, education, disability, urban/rural location (zip code level variables); illness rates (HSA level variables); and region of the country. The odds ratio provides an estimate of the average increase in the odds of death for each additional bed per 1000 across U.S. HRRs.

‡Model for blacks excluded HSAs with fewer than 500 blacks (age 65 years and over).

§Mortality rate and models are for non-blacks only.

Table 3: Associations Between Different Measures of Hospital Resources Across Strata of U.S. Distribution and Medicare Mortality Rate

	*odds ratio**	95% CI
Model 1		
In-area hospital beds (Model 1)		
As continuous variable	1.003	(0.997, 1.009)
Across strata		
Under 2.5	1.000	–
2.5 to 3.5	1.022	(1.004, 1.040)
3.5 to 4.5	1.035	(1.015, 1.056)
4.5 and over	1.030	(1.009, 1.052)
Model 2		
Inpatient days per capita		
As continuous variable	1.076	(1.064, 1.089)
Across strata		
Lowest quartile	1.000	–
Second quartile	1.030	(1.011, 1.049)
Third quartile	1.083	(1.061, 1.106)
Highest quartile	1.114	(1.084, 1.145)
Model 3		
Inpatient days in six months prior to death		
As continuous variable	1.007	(1.004, 1.010)
Across strata		
Lowest quartile	1.000	–
Second quartile	1.040	(1.024, 1.057)
Third quartile	1.079	(1.062, 1.097)
Highest quartile	1.071	(1.049, 1.093)

*Odds ratio derived from logistic regression model, controlling for age, race, and sex (individual level variables); income, education, disability, urban/rural location (zip code level variables); illness rates (HSA level variables); and region of the country. Odds ratio provides estimate of the average increase in odds of death across HRRs at the specified stratum of the U.S. distribution.

in areas of greater per capita bed supply are largely "discretionary" in the sense that similar patients living in low-bedded areas are more often treated outside the hospital.

We recognize that our cross-sectional analyses of the association between increased capacity and mortality represent only a preliminary effort to examine the health outcomes associated with treating these discretionary cases in the inpatient setting as opposed to the outpatient setting. For Medicare enrollees in general and for the subgroups examined, the association between increased hospital capacity and mortality was either flat or positive. In no subgroup were greater inputs of hospital resources associated with lower mortality.

Our inability to detect a beneficial effect of the increased utilization induced by greater hospital capacity could be due to residual confounding. We tried to assess this possibility in several ways. First, we controlled for differences in underlying socioeconomic characteristics and disease burden. Although we used ecologic measures of education, income, poverty status, and disability, such ecologic measures have been shown to provide valid estimates of individual attributes in studies based on census-tract level data (Geronimus, Bound, and Neidert 1996; Krieger 1992) and reasonable proxies in studies based on zip code level data (Gornick, Eggers, Reilly, et al. 1996; Hofer, Wolfe, Tedeschi, et al. 1998). Second, the model that estimated the marginal effects of just those hospital inputs associated with a greater intensity of end-of-life care showed no beneficial effects. As discussed in Table 1, it is possible that the differences in the estimates of the odds ratios between Models 1 and 3 (in Table 3) represent the effect of residual confounding in Model 2. At the same time, it is also possible that the difference between Models 2 and 1 reflects the effect of measurement error, as in-area beds represents a poor measure of the marginal inputs of hospital care to the Medicare population. Third, our models gave consistent results across strata based on population characteristics (age, race, and income) and in strata selected on the basis of health system attributes (models restricted to HSAs with teaching hospitals or to HRRs with a Medicare HMO penetration of 3 percent or less).

Other limitations further underscore the need for caution in interpreting the results of our mortality analyses. The only outcome examined was mortality; it is possible that increased hospital resources are associated with improved functional status or quality of life. Our study also says nothing about the relationship between investments in non-hospital resources and outcomes. It would also be inappropriate to generalize these findings to other populations, such as Medicare beneficiaries enrolled in risk-bearing managed care organizations or to those under age 65. The uninsured may be particularly vulnerable to policies that seek to reduce local acute care capacity, (Bindman, Keane, and Lurie 1990) given their dependence on hospital uncompensated care.

Nevertheless, our findings underscore the need to shift the focus of future research from the causes to the consequences of variations in hospital utilization: what are the benefits (or harms) of the increased utilization caused by greater capacity? Several recent studies suggest that harm is possible (Brennan, Leape, Laird, et al. 1991; Guadagnoli, Hauptman, Ayanian, et al. 1995; Weinberger, Oddone, and Henderson 1996). Could the positive association between increased hospital capacity and mortality that appears in several of our models represent a causal relationship? Given the limitations of our data set, our analyses can do no more than raise the possibility. Further work will be required to learn how and when capacity-driven utilization leads to benefit or harm.

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