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A Variable-Radius Measure of Local Hospital Market Structure

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Objective. To provide a radius measure of the structure of local hospital markets that varies with hospital characteristics and is available for all hospitals in the United States.
Data Sources. 1982 American Hospital Association (AHA) Survey of Hospitals, 1982 Area Resource File (ARF), and 1983 California Office of Statewide Health Planning and Development (OSHPD) discharge abstracts.
Study Design. The OSHPD data were used to measure the radii necessary to capture 75 percent and 90 percent of each hospital's admissions. These radii were used as the dependent variables in regression models in which the independent variables were from the AHA and ARF. To estimate predicted market radii, the estimated parameters from the California models were applied to all nonfederal, short-term, general hospitals in the continental United States. These radii were used to define each hospital's service area, and all other hospitals within the calculated radii were considered potential competitors. Using this definition, we calculated two measures of local market structure: the number of other hospitals within the radius and a Herfindahl-Hirschman Index based on the distribution of hospital bed shares in the market.
Data Extraction Methods. These measures were calculated for all nonfederal, short-term, acute care hospitals in the continental United States for whom complete data were available (N = 4,884).
Conclusions. These measures are available from the authors on computer-readable diskette, matched to hospital identifiers.

Keywords. hospital market structure

Since hospitals operate in a competitive environment, it is necessary to control for the effects of competing hospitals when studying hospital behavior. The method used to identify competing hospitals should be matched to the research question (Garnick et al. 1987; Luft et al. 1989). While antitrust definitions of markets are probably the most familiar to economists, they are not necessarily the most appropriate. For many applications, a measure of the structure of a hospital's service

area (the area from which a hospital draws most of its patients) may be more appropriate than a measure of the structure of its economic or geographic market.

Researchers have used several different methods of measuring a hospital's market to study aspects of hospital behavior. The simplest and most readily available measures have been based on county level data (for example, Joskow 1980). Luft and Maerki (1984) proposed using a 5-mile or a 15-mile radius to identify a hospital's service area. This measure of local market structure has been used in many studies of hospital behavior (Luft, Robinson, Garnick, et al. 1986; Robinson and Luft 1985, 1988). Recently, several studies have used the zip code of patient residence from discharge abstracts to define hospital service areas (Robinson and Phibbs 1989; Zwanziger and Melnick 1988).

While the county and fixed-radius measures are readily available for all hospitals, they do not account for differences in local market characteristics and the types of services provided by each hospital. Thus, these measures cannot adjust for factors that are known to affect the size of a hospital's service area (Erickson and Finkler 1985; Luft, Garnick, Mark, et al. 1990). Through their use of actual patient flows, the zip code measures implicitly adjust for the differences in hospital and local market characteristics.

While zip code–based measures of local hospital market structure have been used at the state and local level, to construct such measures for the whole nation would be a massive undertaking. Further, since nationwide patient discharge data are available only for Medicare patients, some types of patients would be excluded (e.g., pediatric and

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obstetric patients). To fill this gap until such measures can be constructed, we propose a variable-radius measure to define a hospital's service area based on hospital characteristics and characteristics of the local population. Conceptually, this measure can be thought of as an adjustment to the fixed 15-mile radius measure. The purpose is to provide measures of hospital service area and local market structure that are derived (indirectly) from patient flow data, yet are available for all hospitals in the continental United States. We make these measures of market structure available on an ASCII file, matched to American Hospital Association (AHA) hospital identifiers.

DATA

The 1983 patient discharge abstracts from the California Office of Statewide Health Planning and Development (OSHPD) were used to calculate the observed radii for California hospitals. Data on the characteristics of individual hospitals were obtained from the 1982 AHA Annual Survey of Hospitals. County level demographic data were obtained from the 1982 Area Resource File (ARF) compiled by the Bureau of Health Professions, U.S. Department of Health and Human Services. Each California hospital was classified as urban if it was located within an "urbanized area," as defined by the U.S. Census (1980a, 1980b).[1] The 1982 hospital and area characteristics were matched with 1983 patient flow data to allow for lags in the adjustment of patient flows to changes in hospital characteristics.

We used data on all nonfederal, nonspecialty, short-term hospitals in California, with a number of exceptions. Hospitals that predominantly served HMO populations (e.g., Kaiser hospitals) were excluded.[2] We also excluded hospitals in rural vacation areas that received a large portion of their admissions from distant urban areas, because these hospitals were obviously not in direct competition with the hospitals in urban areas.[3]

National estimates of local hospital market structure were produced from the AHA and ARF data. The selection criteria of nonfederal, nonspecialty, short-term hospitals in the continental United States reduced the AHA data set from about 5,500 hospitals to 4,884 hospitals. The special exclusion criteria applied to the California data (e.g., hospitals in rural vacation areas) were not used for the national data because they could not be applied consistently across all states.[4]

METHODS

CALCULATION OF ACTUAL MARKET RADIUS FOR CALIFORNIA HOSPITALS

To calculate the actual market radius, the California discharge abstracts were aggregated into zip code–hospital pairs. The distance from the exact location (longitude, latitude) of the hospital to the post office of each zip code was calculated for all zip code–hospital pairs.[5] The zip code–hospital pairs were then rank-ordered by distance for each hospital. These distributions of patients over distance were used to calculate the radii that were necessary to capture at least 90 percent and 75 percent of each hospital's patients, respectively.

STATISTICAL MODEL

These measured radii for California hospitals were used as the dependent variables in two regressions (90 percent and 75 percent measures), where the regressors were variables from the ARF and AHA data to control for area and hospital characteristics that might influence the size of hospital service areas. The independent variables included population density of the county,[6] hospital size, number of other hospitals within 15 miles, log of cost per admission at the hospital, teaching status (member of the Council of Teaching Hospitals, medical school affiliation, and house staff per bed), ownership status, percent of admissions reimbursed by Medicaid, percent of admissions reimbursed by Medicare, and controls for the clinical services offered by each hospital.[7] The inclusion of market structure variables based on the fixed 15-mile radius highlights the manner in which the variable radius measure should be conceptualized as an adjustment to the basic geographic measure.[8]

NATIONAL ESTIMATES OF MARKET RADII

The coefficients from the estimates using the California sample were applied to our AHA sample. The predicted market radius for each hospital was computed by multiplying values of the hospital's institutional and county characteristic variables (from the AHA and ARF) by the estimated parameters obtained from the California regressions. These radii can be considered estimates of the size of each hospital's service area. To limit the effect of outliers, predicted radii falling below the first percentile or above the 99th percentile were assigned the radii of the corresponding percentile.

Two measures of market structure of the area from which a hospital draws its patients were computed based on this definition of hospital service area: the number of hospitals within a circle defined by the predicted radius (not counting the target hospital) and the Herfindahl-Hirschman Index (HHI), where the HHI is calculated as the sum of the squared market shares for all hospitals in the local market. Market shares were defined in terms of the proportion of total staffed beds in the market associated with each particular hospital.

RESULTS

Table 1 presents the results for the regression model estimated on data from California hospitals. The model explains 35 percent of the variance in the radius necessary to capture 90 percent of a hospital's admissions and 26 percent of the variance in the radius necessary to capture 75 percent of a hospital's admissions. Hospitals in more sparsely populated counties tend to have larger radii, and the radii tend to increase with hospital size; teaching status and cost per admission are also associated with larger radii. As expected, smaller radii are observed for public and proprietary hospitals, but these effects are not significant. Larger Medicaid and Medicare shares reduce the radius necessary to attract patients.

Hospitals with only one neighbor are not significantly different from those with no neighbors. Hospitals with two to four neighbors have significantly larger radii. Above two to four neighbors, the radii decrease as number of neighbors increases, but the coefficients are not significant. Most of the service scores are not significant.[9]

Table 2 presents the distributions of the actual and predicted radii for California hospitals, and the predicted radii and market structure measures for U.S. hospitals. For California hospitals, the distributions of the predicted radii are quite close to those of the actual radii. Our analysis of the regression residuals found that most of the prediction errors were due to poor prediction at the extreme tails of the distribution. The distributions of the predicted radii for the U.S. hospitals are similar to those from California. The slightly higher national mean is expected, given the higher proportion of rural hospitals in the United States as compared to the proportion in California.

The 90 percent measure's wider definition of hospital service area is reflected in market structure measures. The 90 percent measures define many more hospitals as competitors than do the 75 percent measures, with a mean count of competitors of 9.7, compared to 3.9

Table 1: **Regression Results for California Hospital (N = 355)**

	75% Radius	*90% Radius*
Intercept	-7.743	-32.647
	(9.962)†	(20.741)
Population density ≤40	7.977***	14.854***
	(1.698)	(3.536)
Population density 40-200	5.012***	7.266**
	(1.332)	(2.774)
Population density 200-1,000	2.430*	1.123
	(1.175)	(2.447)
Population density 1,000-2,000	-0.319	-3.017
	(0.962)	(2.002)
Log cost per admission	2.108*	7.765***
	(1.120)	(2.498)
100-199 beds	0.888	1.015
	(0.845)	(1.759)
200-299 beds	0.588	2.112
	(1.183)	(2.462)
300-399 beds	0.039	4.700
	(1.569)	(3.267)
>400 beds	1.977	7.253*
	(1.978)	(4.118)
Member, Council of Teaching Hospitals	1.740	7.779*
	(1.779)	(3.704)
Medical school affiliation	4.316***	7.185**
	(1.251)	(2.604)
House staff per bed	-1.730	3.383
	(1.609)	(3.350)
Public hospital	-0.472	-3.682*
	(0.802)	(1.671)
Proprietary hospital	-0.577	-1.569
	(0.765)	(1.594)
Percent Medicaid admissions	-0.090***	-0.220***
	(0.026)	(0.055)
Percent Medicare admissions	-0.076*	-0.180**
	(0.033)	(0.068)
1 other hospital within 15 miles	0.530	-1.169
	(1.424)	(2.965)
2-4 other hospitals within 15 miles	3.359**	6.026*
	(1.387)	(2.889)
5-10 other hospitals within 15 miles	1.987	2.204
	(1.490)	(3.103)
≥11 other hospitals within 15 miles	2.355	-1.293
	(1.630)	(3.395)
Score for cardiac services	0.386	-0.517
	(0.558)	(1.162)
Score for other medical services	0.117	-0.048
	(0.396)	(0.825)

Continued

Table 1: Continued

	75% Radius	*90% Radius*
Score for pharmacy services	0.388	0.617
	(0.454)	(0.946)
Score for ICU services	-0.044	-1.315
	(0.534)	(1.113)
Score for transplant services	2.800***	5.880***
	(0.811)	(1.688)
Score for most basic medical services	-2.507**	-2.708
	(1.011)	(2.106)
Score for basic medical services	-0.535	-1.252
	(0.476)	(0.990)
Score for basic ancillary services	0.363	0.414
	(0.353)	(0.735)
Score for specialized ancillary services	-0.301	0.210
	(0.468)	(0.975)
Score for psychiatric services	-0.848	-1.783
	(0.520)	(1.082)
Score for pediatric services	-0.526	0.025
	(0.457)	(0.951)
Score for newborn services	-0.122	-1.341
	(0.495)	(1.030)
Score for radiation therapy services	0.358	0.369
	(0.405)	(0.844)
Adjusted R^2	.0.26	0.35

*$p < .05$.

**$p < .01$.

***$p < .001$.

†Standard errors in parentheses.

for the 75 percent-based definition. The counts of competitors range from a minimum of zero (no other institutions within the estimated variable market radius) to a maximum of 147 for the 90 percent-based measure and 99 for the 75 percent-based measure. A similar pattern is observed for the HHIs: the increased number of competitors for the 90 percent-based measure yields lower HHIs (less concentrated markets).

Although not shown in the tables, we compared the market structure measures obtained from our predicted radii with the 15-mile radius of Luft and Maerki (1984) and a patient flow-based measure of the competitiveness of a hospital's service area (Robinson and Phibbs 1989). We assumed that the patient flow measures are the best indicator of the actual size of hospital service areas. Our variable-radius measures tended to fall in between the 15-mile radius measures and those derived from actual patient flows. For all hospitals and for urban

Table 2: Descriptive Statistics for Variable Radii and Market Structure Measures Based on the Variable Radii: California Hospital (N = 355) and U.S. Hospitals (N = 4884)

	Mean	*Median*	*Standard Deviation*	*Minimum*	*Maximum*
Radius for 90% of Patient Admissions					
Actual radius, California (miles)	17.83	14.00	12.68	0.60	124.44
Predicted radius, California (miles)	17.82	17.19	7.91	4.74	42.55
Predicted radius, United States (miles)	19.42	18.80	7.35	4.74	42.55
Number of competitors	9.66	3.00	19.50	0.00	147.00
Herfindahl-Hirschman Index	0.4512	0.3497	0.3544	0.0144	1.00
Radius for 75% of Patient Admissions					
Actual radius, California (miles)	8.43	7.33	5.68	0.25	65.48
Predicted radius, California (miles)	8.42	7.87	3.16	3.02	18.46
Predicted radius, United States (miles)	9.03	8.75	2.94	3.02	18.46
Number of competitors	3.88	1.00	9.27	0.00	99.00
Herfindahl-Hirschman Index	0.6567	0.8443	0.3690	0.0286	1.00

hospitals, the variable-radius estimate shows less competition than the 15-mile radius measure and is closer to the patient flow estimate than to the 15-mile fixed-radius estimate. Conversely, for rural hospitals, the variable radius tends to increase the measured competitiveness, compared to the 15-mile radius measure, but to show less competition than was estimated by the patient flow measure.[10]

DISCUSSION

Our intention is to provide researchers with new measures of hospital service area and local hospital market structure for use in empirical studies of hospital behavior. The specific advantage of our measures is that they are available for all hospitals in the continental United States. Because there is some debate about the appropriate definition of market area, we have included four estimates of local market structure. The radius necessary to capture 90 percent of a hospital's patients is a very broad definition of a hospital's service area. The smaller 75 per-

cent radius is similar to the definitions used by others (Garnick et al. 1987; Zwanziger and Melnick 1988). The narrower focus of the 75 percent definition reduces the probability of including noncompetitors, but it also increases the probability of excluding a hospital that should be included. For each of these definitions of market scope we have measured market structure in terms of both the Herfindahl-Hirschman Index and the more easily interpretable number of competitors.

Although the models upon which our measures are based were estimated using California data, we believe that they are also applicable to the rest of the country. California is the largest and most diverse state in the continental United States. It includes large urban areas of various densities, areas of suburban sprawl, isolated smaller cities, and both farming and nonfarming rural areas where population densities vary. Thus, the variance in California population densities and community types covers the range seen in the continental United States. The one significant difference between the national and California samples is that there are more rural areas in the entire United States than there are in California, and thus that there are more rural hospitals in the rest of the United States. Although our data have fewer rural hospitals than the rest of the United States, 25 percent of the California hospitals are located in rural areas. Further, there is diversity among the rural areas in which these hospitals are located: there is variation in the population density of the farming areas, and about one-third of the rural hospitals are located in nonfarming communities. The diversity of California's urban population is definitely sufficient to allow projections of the other urban areas of the United States, with the possible exception of New York City.

We believe that the variable-radius measures of hospital service areas are superior to the geopolitical measures and are an improvement on the fixed 15-mile radius measure. The variable radius is able to adjust for differences in local population density and in hospital characteristics. Measures based on patient flow data have the potential to yield a better definition of a hospital's current market than the variable-radius measure described here, but patient flow–based measures are not currently available on a nationwide basis. The variable-radius measure addresses the major problem of the 15-mile radius, its tendency to overestimate the degree of competitiveness in urban markets and to understate it in rural markets (Garnick et al. 1987).

Our variable-radius measures are designed to be applied in population-based or large cross-sectional studies, not in studies of individual hospitals. Thus, it would not be appropriate to use them to classify individual hospitals. For example, it would be inappropriate to

use them to determine which hospitals should be classified as sole community hospitals under the prospective payment system.

These variable-radius measures of hospital service area are proposed as an improvement over what is currently available to researchers. We consider them an interim measure until patient flow-based measures are available on a national basis. We hope that our provision of these variable-radius measures to other researchers will stimulate research to develop and make available other measures of market structure, and that applied research into the performance of health care markets will be thereby improved.

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NOTES

1. The U.S. Census defines an urbanized area as any city that, including its contiguous suburbs, contains at least 50,000 people.
2. This restriction was to eliminate those hospitals essentially closed to patients who were not members of the sponsoring HMO. All other hospitals were retained, regardless of the proportion of their patients covered by HMOs.
3. Additionally, 64 hospitals were dropped because of incomplete AHA data, as were six hospitals in urban areas with fewer than 30 beds, a hospital on an Indian reservation, and student hospitals on university campuses. To confirm that these omissions did not bias the results, we estimated a similar model using OSHPD hospital data, which allowed us to include most of the hospitals omitted due to incomplete data. The results from the models estimated using the OSHPD data were very similar to those reported in this article. For more details on these exclusions, see Phibbs (1987).
4. We did exclude very small (<30 beds) hospitals in large urban areas (population density greater than 2,000 per square mile): there were no such hospitals outside of California in our AHA data set.
5. These calculations are described in more detail in Garnick et al. (1987).
6. Differences in the population density of a county generally reflect the degree of urbanization. In California, Riverside and San Bernardino counties are exceptions to this rule. Both of these counties are very large and located east of Los Angeles. Their western areas are part of the greater Los Angeles urban area, but most of the area of both counties is sparsely populated desert. To ensure that the special nature of these counties did not bias the results, we reestimated the model after deleting all of

the hospitals in these counties. Since these results were virtually identical to those from the analyses that included Riverside and San Bernardino counties, these hospitals were incorporated in the final analyses.

7. The correlation among the services provided by hospitals precludes including all of them in the regression model. Instead of arbitrarily excluding services, we created scores for various types of services (details available from authors). These aggregations reduced the collinearity among the variables such that relatively stable parameter estimates could be obtained, but some collinearity remained.
8. Although the estimates reported here represent the full California sample, the model was originally estimated using a random sample of half of the California hospitals and was validated with the remaining data.
9. There were no systematic differences in the residuals by teaching status, hospital size, ownership, urban versus rural, rural farming versus rural nonfarming, or small urban versus suburban fringe of large urban areas. The results were also robust to the exclusion of teaching and public hospitals.
10. These and all other unreported statistics are available from the authors.

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