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# A Guide to the Delineation of Medical Care Regions, Medical Trade Areas, and Hospital Service Areas

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PLANNERS AND OTHERS interested in the economics of medical care distribution often have difficulty in estimating the land area and population base served by the physicians and medical facilities located in a town or city. In the case of regional jurisdictions, the land areas of regions are often designated on the basis of political considerations, such as State and county boundaries, alliances between agencies, or Federal or State criteria. For example, Federal standards for health systems agency (HSA) areas specify that boundaries must coincide with State or county boundaries, encompass a population of 500,000 persons, and include a tertiary medical care center.

Problems associated with regions based on political boundaries are that the data for the region may not supply information for estimating need, effective demand, or even the supply of medical services in the area. The population base of a health systems agency region may be larger or smaller than that actually served by the supply of medical services located in towns within the HSA area because some populations may travel to medical care outside the region for primary, secondary, or tertiary services. People in some areas may have difficulty in deciding which HSA to affiliate with, since ties are equally strong to services in several nearby cities. An adequate population estimate is particularly important to HSAs when certificate of need applications are being evaluated.

A method for the delineation of medical care regions, medical trade areas, and hospital service areas, as characterized by the flow of trade, is described here. One can estimate the population base of an area after it is delineated by combining census tracts, county census divisions, and State, county, and city population data.

A *medical care region* is defined as the land area around a major city having tertiary services; it includes towns offering primary and secondary medical services

within the region. Physicians and medical facilities located in towns throughout the region obtain referral, consultation, assistance, and support services from physicians located in the major city, which has the largest number of medical services in the region.

A *medical trade area* is the land area served by an individual town where physicians provide patient care. A medical care region often has several medical trade areas within it.

A *hospital service area* is the land area served by a town that has at least one hospital; it may include several towns where physicians are in practice.

## Delineating Medical Care Regions

A road map or National Geological Survey map of the State and nearby areas that shows highways and county boundaries is needed. Due north should be at the top of the page. The locations of towns with physicians can be marked with small labels or a felt marking pen. Data sources for the locations of physicians are a cross-check of the American Medical Directory, telephone books, health systems agency data, and lists of hospital staffs. A worksheet listing all physician specialties, as shown in table 1, should be available for each county. A ruler may be used for estimating distances between towns because air miles are the correct distances for regional analysis. A calculator is also needed.

**Identifying regional centers.** First, the locations of towns having physicians in practice, as listed in the American Medical Directory and other available data sources, are marked on the map. Next, the presence of each speciality listed on the worksheet for each town with physicians is checked off and counted. The number of physician specialties in each town is a measure of the town's importance in the delivery of medical care and its attraction to the people living near it. Table 1 is an example of the count of number of specialties in towns of Stanislaus County, Calif. The maximum number of specialties possible is about 70, as listed by the American Medical Association.

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Each specialty, including general practice, is counted as one point in the tally. Since each physician is permitted to list two specialties in the American Medical Directory, a town with 10 physicians has a potential of 20 specialties, or 20 points. If the 10 physicians practice a combination of general practice, internal medicine, pediatrics, cardiology, and obstetrics, the town would have a count of 5 specialties. Only the physician whose home office is located in the town is counted; specialists with office hours in several towns are counted as located at their main office. Sister cities and contiguous cities are counted as one location.

After the number of specialties in each town is counted, the town may be classified. The nation's largest metropolitan centers, such as Los Angeles, San Francisco, Chicago, and New York, are classified as national centers. In California, cities having from 40 to 50 specialties are classified as regional centers—for

example, Fresno, Bakersfield, Santa Barbara, Sacramento, and San Jose. Cities having from 30 to 40 specialties are intermediate centers—for example, Stockton, Monterey, Modesto, Santa Cruz, and Reno. Towns with 16 to 30 specialties are local centers—for example, Placerville, Auburn, Lodi, and Woodland. Towns with fewer than seven specialties (the mean for the data set) are called primary care centers. The regional centers identified by this procedure are often the same cities called "regional business centers" by the Rand-McNally City Rating Guide (1).

As shown in figure 1, the number of specialties located in each town is encircled on the map, and towns with fewer than two specialties are marked with dots.

The procedure described identified the towns within a region that are "collectors" of patients from primary care centers, and they may refer patients to secondary

Table 1. Worksheet for counting physician specialties; Stanislaus County, Calif.

Physicians' specialties	Modesto	Turlock	Oakdale	Patterson	Riverbank	Newman	Hughson	Waterford	County total
1. General practitioner	x	x	x	x	x	x	x	x	x
2. Internal medicine	x	x	x						x
3. General surgery	x	x	x	x		x			x
4. Psychiatry	x	x							x
5. Obstetrics and gynecology	x	x							x
6. Pediatrics	x	x							x
7. Anesthesiology	x	x	x						x
8. Orthopedic surgery	x	x							x
9. Radiology	x	x							x
10. Ophthalmology	x								x
11. Pathology	x								x
12. Urology	x	x							x
13. Cardiology	x	x							x
14. Otolaryngology	x								x
15. Dermatology	x								x
16. Diagnostic radiology	x	x							x
17. Public health									
18. Neurology	x								x
19. Neurosurgery	x								x
20. Plastic surgery	x								x
21. Child psychiatry	x								x
22. Occupational medicine	x		x	x					x
23. Thoracic surgery	x								x
24. Allergy	x	x							x
25. Pulmonary disease	x								x
26. Gastroenterology	x	x	x						x
27. Therapeutic radiology	x								x
28. Physical medicine									
29. General preventive medicine	x								x
30. Colon and rectal surgery									
31. Pediatric cardiology									
32. Pediatric allergy									
33. Forensic pathology	x								x
34. Aerospace medicine									
35. Other	xxxxx	xxx	xx	x	xx				+6
Number of specialties	33	17	8	4	3	2	1	1	35
Number of physicians	222	34	10	5	3	2	1	1	278

SOURCE: American Medical Directory, 1973.

and tertiary care centers when necessary. The regional center was also identified. Patterns for the location of collector and referral towns can be seen in figure 1. First, clusters of cities with larger numbers of specialties are located near the regional center and along the main highways. Then, a ring of cities delineates the inner Sacramento region, cities having from 18 to 25 physician specialties—Auburn, Placerville, Lodi, Woodland, Marysville, and Davis. An outer ring of cities, having from 31 to 38 specialties, collects and refers patients from the towns at the farthest periphery of the Sacramento region—Reno, Stockton, and Fairfield. Each of these cities has its own medical trade area.

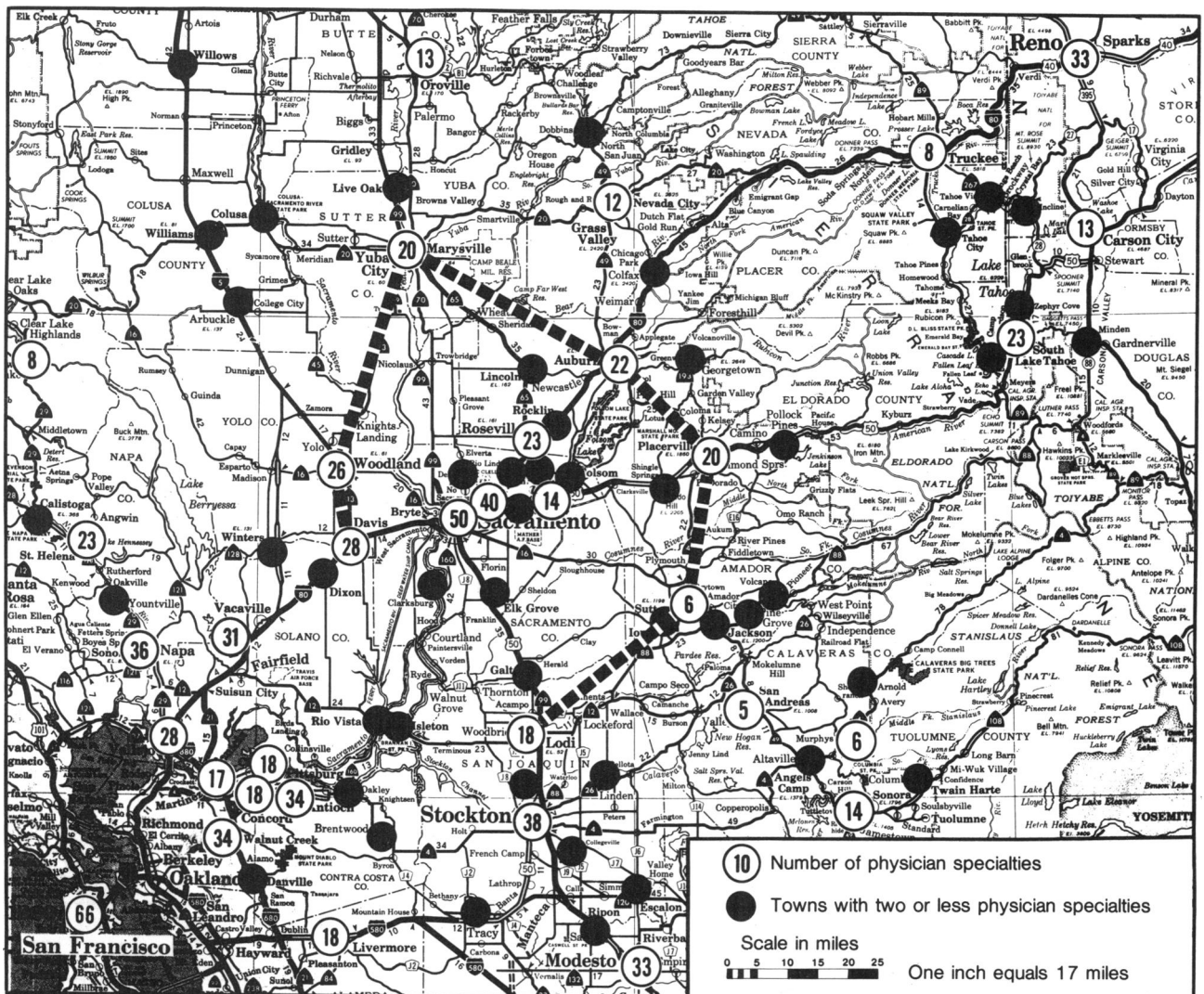
The next step is to locate the boundaries between regions.

### Location of boundaries between medical care regions. Some procedures for locating the boundaries between

medical care regions use secondary data, others primary data. If possible, it is best to first estimate the location of the boundaries by the use of formulas and geography and then verify their location from information obtained from local sources.

In general, the boundaries between medical care regions are not distinct unless they coincide with geographic barriers such as mountains, lakes, deserts, or other sparsely settled places. A town is often located on the boundary between two regions; it fills a gap in services in the area between regions. Physicians practicing in towns located within a region usually send patients directly to the nearest regional center for higher levels of care. However, physicians on the border between regions may send patients in several directions, perhaps to both regional centers and the intermediate cities of both regions. People in towns located on the boundary between regions often have difficulty in

Figure 1. Mapping the distribution of medical services in the Sacramento medical care region



deciding on their regional affiliations with such organizations as health systems agencies.

**Secondary data.** Data from county studies of patient origin may be used to locate counties containing the boundaries between medical care regions. The direction of patient flow from counties with towns having lower numbers of physician specialties to counties having greater numbers of specialties can be plotted. Counties with patients traveling in several directions are those containing the boundaries between medical care regions.

Several formulas are presently available for estimating the approximate location of boundaries between regions. The most commonly used is Reilly's formula, which is based on a gravitational model estimating the attraction of a town for the people of the land area (2). I have devised a formula that is a strict percentage of the distance between towns according to the extent of their centrality, in this case, number of physician specialties (3). Until further experimentation is possible, I propose use of both formulas, which are as follows:

**Reilly's formula:**

$$1 + \sqrt{\frac{\text{Distance from city A to city B}}{\frac{\text{Number of specialties in city A}}{\text{Number of specialties in city B}}}} = \text{Boundary between regions served by cities A and B}$$

**Example:**

$$1 + \sqrt{\frac{\text{Distance between Fresno and San Jose} \quad 126}{\frac{\text{Number of specialties in San Jose}}{\text{Number of specialties in Fresno}}}} = 62 \text{ miles from Fresno; } 64 \text{ miles from San Jose}$$

**Smith's formula:**

$$\frac{\text{Number of specialties in city A}}{\text{Sum of specialties in cities A and B}} \times \text{Distance between cities A and B} = \text{Location of boundary between regions}$$

**Example:**

$$\frac{\text{Number of specialties in San Jose} \quad 49}{\text{Sum of specialties in San Jose and Fresno} \quad 49 + 46} \times 126 = 64.9 \text{ miles from San Jose; } 61.1 \text{ miles from Fresno}$$

Although the difference in miles between the two formulas is small, my formula tends to place the boundary between regions on a boundary town, while Reilly's formula tends to miss towns.

A third formula for the location of boundaries between regions is based on Christaller's theory of loca-

tion (4). Boundary towns on major highways or waterways will be found halfway between regional centers. Boundary towns located in areas where through traffic is difficult will be found at the distance between regional centers divided by the  $\sqrt{3}$ . Most regions of California have both kinds of boundary towns in their areas. All three formulas for locating boundaries could be used for comparison of the findings.

**Primary data.** After the approximate locations of boundaries between regions have been found by the use of secondary data, local information sources can be used to locate the actual boundary. Data sources may include newspaper articles on prominent citizens and their hospitalizations, obituaries, and speeches by local officials. Other sources are the list of staff and consulting physicians at local hospitals, telephone calls to the local pharmacists and hospital administrators, and reports on health services.

For example, when delineating the medical care region of Bakersfield, I found that the patient origin study and calculations of formulas placed the boundary between the Bakersfield and Fresno regions between Visalia and Porterville in Tulare County. The hospital administrator at Lindsay told me, by telephone, that "95 percent of the patients from Lindsay and Strathmore go toward Fresno, but people in Porterville go toward Bakersfield." A Chamber of Commerce brochure for Porterville and other towns of the area also showed that patients tend to go to Bakersfield. In another case, the staff and consultation privilege list from the hospital at Ridgecrest showed that most specialists come from Riverside and Los Angeles and that Ridgecrest is not in the Bakersfield region.

In Merced, however, the properties of a boundary town are more evident. In a call to the hospital in Merced, I found that it sends patients to Modesto, Fresno, and Oakland. Patients in the complex of towns on the boundary between the Fresno, Oakland, and San Jose regions go in several directions for medical care.

In the mapping process, the boundaries between regions can be approximated with a circle, or drawn in according to roads and geography.

**Diagramming referral paths.** A diagram may be made of the referral paths of patients traveling from the towns with the lowest levels of primary care toward regional and national centers.

First, the air miles between each town with physicians and the nearest regional center are measured. Then, with the regional center as the focal point on the diagram, each town's distance from the regional center

on the horizontal axis and its number of specialties on the vertical axis are marked. Depending on the orientation of the region, the diagram may be on an east-west axis, a north-south axis, or rotated according to the distribution of towns in the particular region.

After roads on the map are examined, the shortest route between towns with the fewest number of specialties through intermediate levels of care to the regional center are diagrammed. Some towns may have roads directly to regional centers, and others may have roads only to local centers, from where patients go to regional centers. When the referral path of patients from a particular town is doubtful because of poor roads, inclement weather, poor maps, or other factors, a knowledgeable person can be asked about local conditions. If possible, information can be obtained by telephoning a newspaper editor, pharmacist, the Chamber of Commerce, a local gas station, or a general store. The flow of trade within a region is generally from the periphery of the region toward the regional center, and it is commonly known within the region.

Figure 2 shows the referral paths of patients within the Fresno region. This region is a flat valley with towns somewhat evenly distributed throughout the area. Diagrams of mountainous regions are more complex.

### Delineating Medical Trade Areas

A medical trade area is the land area around the town where physicians are in practice. The area's population travels to the town for the medical services located there. Among geographers and economists, the medical trade area is called the town's hinterland or service area. However, since this analysis is concerned only with the

distribution of medical services, and every town does not have medical services, the total land area served by a town with physicians is defined as the town's medical trade area.

The purpose of delineating medical trade areas is to obtain data on population size, income level, and social and economic characteristics for estimating the need for medical care among the population of an area, as well as the effective demand for medical services. Once the medical trade area is delineated, it is possible to distinguish various kinds of medical care shortages and to project the amount of medical care a population requires. Among the materials needed are a map of the medical care region, as in figure 1; worksheets listing the number of specialties and the number of physicians in each town, as in table 1; the most recent population figures; a map of county census divisions; a current telephone book for the area; and a compass, a ruler, and a calculator.

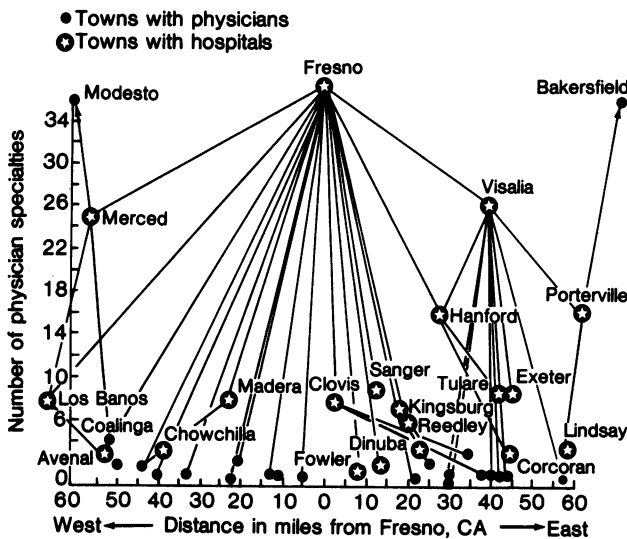
Several principles help to delineate medical trade areas. The greater the number of physicians and specialties at the regional center, the greater the need for locating primary and secondary services in places where the majority of the region's population can be served. The impetus for the distribution of medical service towns throughout a region, therefore, originates at the regional center.

In delineating medical care regions, it is assumed that most people will use the nearest and cheapest medical care, as shown in many hospital discharge studies (5). Furthermore, each town offering medical services to its hinterland or medical trade area enjoys a spatial monopoly over the people in that area, provided that the price of services in the town is competitive with the price of services in the next town (4).

In general, physicians serving populations in outlying areas of a region will refer patients to the nearest town and then to the nearest regional center for secondary and tertiary medical care, rather than in the opposite direction. In some cases, geographic barriers, inclement weather, social problems, State boundaries, or medical school jurisdictions may intervene in the flow of trade. Mountains or deserts, heavy snowfall, or language differences and discrimination may alter the principle of traveling to the nearest (hence cheapest) medical care for most of the population.

The first step in delineating the medical trade area of a town is to examine the town's location relative to all other towns with physicians in the area. There is a hierarchy or order in the distribution of towns with medical services in a region. Towns with larger numbers of specialties may have trade areas that include several towns with smaller numbers of specialties, and towns

Figure 2. Referral diagram of the Fresno medical care region



with small numbers of specialties may have one or two towns with only one physician in their trade areas. At the bottom of the hierarchy are the towns having two or less specialties and trade areas that offer only primary care services.

Two towns with the same number of specialties may have quite different characteristics—one may serve a sparse population spread over a large land area—for example, Merced—while the other may have a dense population and a small land area, as in Visalia (fig. 2).

The boundary between medical trade areas of towns may be approximated by use of either Reilly's or my formula, or both, and supported with primary data, as discussed in the previous section. After the town's medical trade area is delineated, the boundaries of county census divisions may be examined to see if they approximate the outline of the medical trade area obtained by the delineating procedure. Several county census divisions may be combined for this purpose or divided, if necessary. Population figures for county census divisions can then be used to estimate the population base for physicians located in the town.

### **Delineating Hospital Service Areas**

A hospital service area is the land around a town where one or more hospitals are located. The hospital service area may include several nearby towns without hospitals but with physicians in practice.

The same procedures for delineating regions and medical trade areas are employed for delineating hospital service areas. First, the number of physician specialties in towns with hospitals are counted, and regional and local centers are identified. Then, the boundaries between hospital service areas are located by use of formulas and information from local sources. Referral paths from towns with physicians only through towns with hospitals and higher numbers of specialties are diagramed.

Hospital towns form hierarchies of services similar to those of medical trade areas. Some hospital towns offer only primary hospital services, while others have secondary and tertiary care. Hospitals with secondary and tertiary services offer primary care to patients closest to them, secondary care to those referred to them from nearby towns, and tertiary services to residents of the larger land area of a region.

The hospital service area for an individual hospital located in a town with several hospitals may be delineated. Since physicians tend to refer patients to hospitals where they have staff privileges, the addresses of physicians on the staff list provide an indication of the hospital service area. Of course, this does not hold for emergency cases.

The hospital courtesy and staff privileges list also provides information on a hospital's referral patterns. Some specialists from nearby secondary and tertiary centers have staff privileges at smaller hospitals. They are called in for emergencies and special cases, and patients from that hospital are also referred to them. Patient origin studies, of course, provide useful information on hospital service areas. However, they are much more expensive than the method described here.

### **Theory**

The delineation of medical care regions and service areas is based on central place theory, an economic explanation for the location of goods and services. The count of physician specialties in each town is a method for estimating a town's centrality, or importance, in delivery of medical care (4).

Several principles from central place theory aid in the location of boundaries between medical care regions—principles having to do with the reasons for the location of towns and the flow of trade. Towns which were originally founded on thoroughfares, such as highways, railroads, rivers, and oceans, are located according to the traffic principle. In this case, boundary towns between regions are usually found halfway between regional centers. Older towns which were founded before thoroughfares were built are located according to the market principle and are found at the distance between regional centers divided by  $\sqrt{3}$ . A regional boundary without towns on it, where all towns are well within one region or another, is illustrative of the administrative principle and characteristic of towns located near State and national borders. The underlying premise for the traffic, market, and administrative principles is that goods and services are distributed to the people of a land area from as few centers as possible for economic reasons (4).

In California, the administrative principle seems to apply to the medical care regions of national centers; there is a distinct watershed between the land areas served by San Francisco and Los Angeles. On the coast, the boundary is between King City and Paso Robles in a sparsely settled area. Inland, the boundary is located between Strathmore and Porterville, a more densely settled area. Further study must be made to see if such a watershed occurs between other national centers such as Chicago and New York.

In central place theory, regions and medical trade areas are ideally shaped as hexagons. Towns founded according to the traffic principle are located midway along the side of the hexagon, while towns founded according to the market principle are located on the

corners of the hexagon. Each town has approximately six main highways or thoroughfares through it.

In regions, traffic corridors along the major highways between cities are more thickly settled with towns and villages than the areas lying between traffic corridors (6).

In California, air miles were found to be the correct measure for estimating distances between towns with medical care, because most towns were located at their present sites at the time land was surveyed for railroad construction. Units of land measure, that is, sections and townships, were the most important consideration in the siting of towns in the 1870's. Today, in California, radii of service areas of towns with physicians are about 12 miles, the width of two townships, while radii of hospital service areas appear to be 16.9 miles, the diagonal of two townships (3).

Referral diagrams (fig. 2) of towns and their numbers of specialties within a region are usually symmetrical—note the equal numbers of specialties in the towns of Hanford and Porterville, Merced and Visalia, and Madera and Clovis. The symmetry occurs because the number of specialties in each town depends on the number of specialties in the regional and national centers, as well as the town's location relative to other towns offering medical care. Each town has a spatial monopoly on the land area nearest it, if the prices of services are competitive with those of the next town.

The number of specialties in a town at a central location increases with size of population and income level. Constraints on the number of specialties in a town are a function of the range of specialties located at the regional center, which has the competitive advantage of being able to offer a wider variety of specialties. At some point, an equilibrium is reached between the forces tending to increase the number of

specialties in a town and the constraints of trade imposed by the regional center. The equilibrium results in the symmetry of figure 2.

The distribution of medical care in regions diagramed according to distance and number of specialties is based on economic principles; that is, each town competes with the next town for the trade of the population within its service area, all things being equal. However, although most people may frequent the nearest or cheapest medical care, or both, use of medical services generally follows marketing principles based on the population's status, income, and disease characteristics.

After medical care regions, trade areas, and hospital service areas are delineated, population data for regions and medical trade areas can be estimated from the U.S. Census data and other sources. Table 2 compares population and other data for regions and subregions in central California. In the future, regions can be classified by the size of their populations and land areas, their urban or rural nature, and their number of medical services. Shortages of medical care on the regional level can then be designated.

#### References

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Table 2. Demographic data base for medical care regions in central California

Region	Regional demographic data					Regional medical services data <sup>1</sup>		
	Land area (square miles)	Population size	Population per square mile	Estimated per capita income <sup>2</sup>	Radius (miles)	Number physicians	Physician to popula- tion ratio	Number special- ties
Fresno .....	16,138	758,129	46.9	\$2,639	71.6	703	1:1,078	47
Bakersfield .....	7,668	338,178	44.1	2,447	49.4	372	1:909	45
Subregions:								
Salinas-Monterey .....	4,888	295,174	60.4	3,116	39.4	354	1:763	39
San Luis Obispo .....	3,330	105,690	31.7	2,875	32.5	115	1:919	28
Santa Cruz .....	440	123,790	281.3	3,181	11.8	179	1:692	35
Total .....	32,464	1,620,961	49.9	<sup>3</sup> \$3,614	101.6	1,723	1:941	48

<sup>1</sup> American Medical Directory, 1973. <sup>2</sup> 1970 U.S. Census. <sup>3</sup> State.