EVALUATING HOSPITAL PERFORMANCE THROUGH SIMULTANEOUS APPLICATION OF SEVERAL INDICATORS

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INTRODUCTION

Various indicators—including the percentage of hospital beds occupied, the average length of a hospital stay, and the average number of discharges per bed over a given period—are presented from time to time for use by hospital administrators. While it is customary to analyze these and other variables in isolation, simultaneous analysis of all three is rarely done, partly for lack of a suitable way of combining them and assessing them together *(1)*. The object of this article is to describe a way of doing this that is utilized in Colombia to evaluate hospitals. The method was first used in 1976 to study medical and hospital facilities of Colombia's Social Security Agency in the Cauca Valley *(2)*.

MATERIALS AND METHODS

The basic approach employed to combine these three indicators is to graph them on a chart where the average bed occupancy per year (equivalent to the percentage of time an average bed was occupied) is shown on the X axis, and the average annual number of discharges per bed (known as "productivity") is shown on the Y axis. These values provide all the information needed to calculate the length of the average hospital stay ("bed turnover time"), since

$$\frac{365 \times \%\ \text{beds occupied}}{\text{Average no. of discharges per bed in a year}} = \text{Average length of stay (in days)}$$

And indeed, the average length of stay in days can be shown on the graph by drawing straight lines out from the origin *(3)*, each of which represents an average stay of a particular number of days (Figure 1).

Each graph is then divided into four sectors, the borders of which are defined by the average bed occupancy and discharge rates found for a reasonably homogeneous group of hospitals. Each of the sectors thus obtained has the

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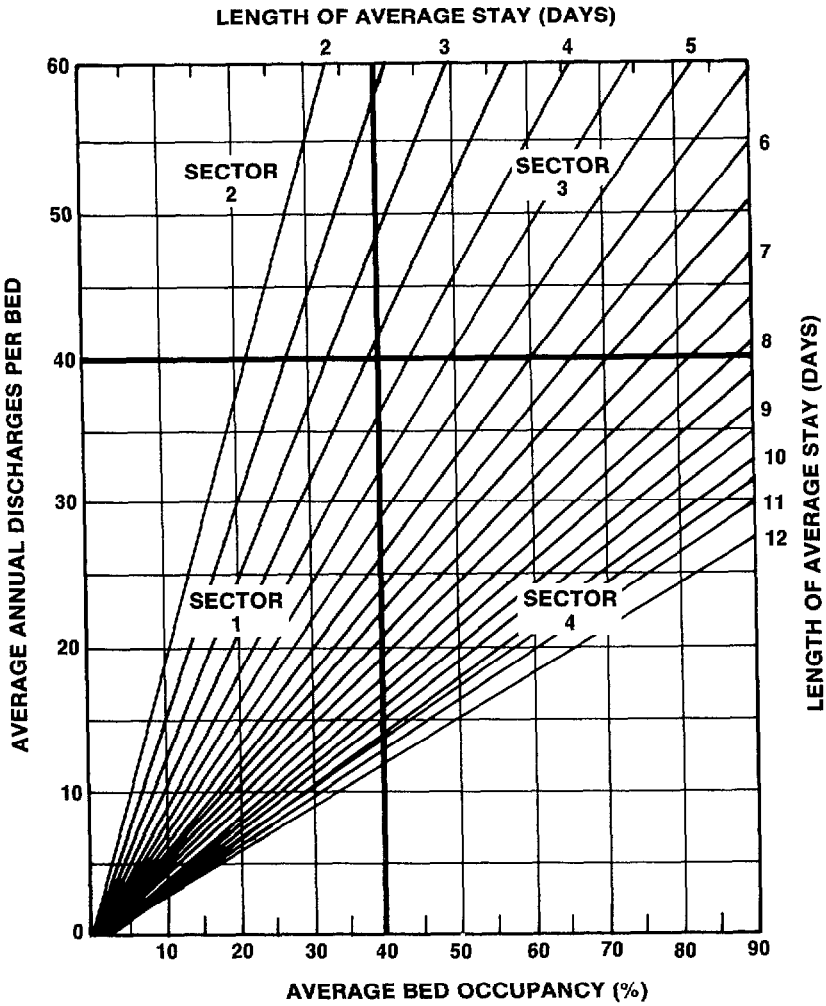
FIGURE 1. A graph for showing average bed occupancy (%), average annual discharges per bed, and average length of stay simultaneously. The occupancy and discharge rates are given by the X and Y axes, respectively, and the length of stay is given by the diagonal lines drawn out from the origin.



following features: Sector 1 (lower left) indicates relatively low levels of bed occupancy and productivity—the least desirable situation; Sector 2 (upper left) indicates relatively low levels of bed occupancy, high productivity, and short hospital stays; Sector 3 (upper right) indicates relatively high levels of bed occupancy and productivity—the most desirable situation; and Sector 4 (lower right) indicates relatively high levels of bed occupancy, low productivity, and long hospital stays (typical for hospitals specializing in chronic diseases).

In general, some of the things to look for at hospitals falling into each of these sectors, assuming the data are not in error, include the following:

Sector 1 hospitals
Excess bed availability
Low need for patient hospitalization
Reduced demand because of patients being diverted to other institutions

Sector 2 hospitals
Excess bed availability
Unnecessary hospitalization
Many beds used for observation of patients
Predominance of normal (as opposed to abnormal) deliveries

Sector 3 hospitals
Good quantitative performance
Small proportion of unused beds

Sector 4 hospitals
High proportion of severe cases
Predominance of chronic cases
Unnecessarily long stays

In addition, when evaluating hospital performance, it is necessary to consider the hospital's size (the number of beds gives a good indication of size) and the types of cases being treated. Also, in fixing the limits of adequate performance, it seems appropriate to allow for a margin of variation such as one standard deviation from the mean.

Hospitals Studied

The data employed here as an illustration (see Tables 1–3) were collected by the Research Program for Health Services Development (Programa de Investigación y Desarrollo de Servicios—PRIDES) in connection with a survey of regional hospitals performed for Colombia's Ministry of Health in 1981 *(4)*. That survey sought general financial and service information by mail for 1977–1980 from each of the 105 institutions listed as regional hospitals by the Ministry of Health in 1979. Not all of these responded, but those that did were

TABLE 1. Average bed occupancy, length of stay, and productivity at 73 of Colombia's regional hospitals in 1977 and 1980, showing upper and lower 95% confidence limits.

Hospital group, hospital size, and number of hospitals included	1977			1980		
	Bed occupancy (%)	Length of stay (days)	Productivity (bed turnovers per year)	Bed occupancy (%)	Length of stay (days)	Productivity (bed turnovers per year)
Group 1 (small, < 100 beds, n = 44):						
Average value	55.7	5.8	38.9	55.0	5.2	42.8
Upper limit[a]	70.3	6.2	42.5	69.7	5.6	47.0
Lower limit[a]	41.1	5.3	35.3	40.3	4.7	38.4
Group 2 (medium, 100–199 beds, n = 20):						
Average value	62.4	6.8	34.9	60.9	6.0	38.7
Upper limit	83.6	7.4	39.3	82.3	6.6	43.9
Lower limit	41.2	6.2	30.6	39.5	5.4	33.6
Group 3 (large, ≥ 200 beds, n = 9):						
Average value	72.0	7.8	34.5	73.0	7.2	37.8
Upper limit	101.3	8.5	38.3	101.9	7.8	41.8
Lower limit	42.7	7.1	30.7	44.1	6.6	33.8

Source: PRIDES report *(4)*.
[a] The upper and lower limits are the values at which the divergence from the average value becomes statistically significant (P = 0 05)

TABLE 2. Distribution of Colombian regional hospitals in the four performance sectors (see Figure 1) as of 1977 and 1980, by size category. The letters "ST" indicate the subtotal of hospitals in each sector.

Performance sector	Size category[a]	Regional hospitals in 1977 No.	Regional hospitals in 1977 %	Regional hospitals in 1980 No.	Regional hospitals in 1980 %	% change
Sector 1	1	17		17		0
	2	8		4		−50
	3	3		3		0
	ST	28	35.0	24	33.0	−6
Sector 2	1	8		4		−50
	2	4		3		−25
	3	1		—		−100
	ST	13	17.0	7	9.0	−46
Sector 3	1	14		16		+14
	2	4		6		+50
	3	3		3		0
	ST	21	27.0	25	34.0	+19
Sector 4	1	10		11		+10
	2	5		5		0
	3	2		2		0
	ST	17	21.0	18	24.0	+6
Size category subtotals	1	49		48		
	2	21		18		
	3	9		8		
Total		79	100	74[b]	100	

[a] Size category 1 includes those hospitals with under 100 beds, category 2 includes those with 100–199 beds, and category 3 includes those with at least 200 beds.

[b] Five hospitals' 1980 data were excluded because of internal inconsistencies.

included in the survey. Differences in the total number of hospitals providing data for different years led to differences in the numbers considered—the specific number generally being between 70 and 80.

In addition, more detailed administrative and financial information was obtained from a representative sample of 20 regional hospitals stratified according to size (number of beds) and location within the country (by political subdivision). These 20 hospitals were selected from among the 76 regional institutions that met all the more stringent requirements established by our definition of a regional hospital.

Survey Data

The survey information needed to determine bed occupancy per year and discharges per bed includes the number of beds in use (installed), the number of beds occupied each day throughout the year (referred to as "occupied bed-days," or OBDs), and the number of discharges in a given period (such as a year). The average annual turnovers per bed (productivity) can then be derived by dividing the number of discharges by the number of beds; the average bed occupancy can be found by

TABLE 3. Average bed occupancy, length of stay, and productivity at 44 of Colombia's smaller regional hospitals (all with less than 100 beds) in 1977 and 1980, grouped according to the regional (multidepartmental) subdivisions shown in Figure 4. This table also shows upper and lower 95% confidence limits for each average listed.

Region and number of hospitals included:	1977			1980		
	Bed occupancy (%)	Length of stay (days)	Productivity (bed turnovers per year)	Bed occupancy (%)	Length of stay (days)	Productivity (bed turnovers per year)
Region A (n = 9):						
Average value	59.6	5.6	41.9	59.7	5.2	42.4
Upper limit[a]	91.6	6.2	49.6	91.7	5.8	47.6
Lower limit[a]	27.6	4.9	34.3	27.6	4.7	37.2
Region B (n = 10):						
Average value	57.9	4.9	42.7	51.2	4.5	47.0
Upper limit	88.5	5.6	44.7	82.1	5.3	50.8
Lower limit	27.3	4.3	40.8	20.3	3.8	43.2
Region C (n = 9):						
Average value	54.9	6.9	30.5	55.2	6.6	32.8
Upper limit	86.9	7.6	34.8	89.2	7.7	38.0
Lower limit	22.9	6.2	26.1	21.2	5.5	27.6
Region D (n = 7):						
Average value	54.4	5.8	34.7	50.5	5.2	36.7
Upper limit	91.2	6.4	38.3	87.5	5.9	41.2
Lower limit	17.4	5.2	30.3	13.5	4.5	32.2
Region E (n = 9):						
Average value	50.3	5.7	43.5	59.5	4.7	52.2
Upper limit	82.3	7.5	55.7	91.5	5.6	68.1
Lower limit	18.3	3.9	31.4	27.5	3.9	36.4
Total (all regions, n = 44):						
Average value	55.7	5.8	38.9	55.0	5.2	42.8
Upper limit	70.3	6.2	42.5	69.7	5.6	47.0
Lower limit	41.1	5.3	35.3	40.3	4.7	38.4

Source: PRIDES report *(4)*.
[a] The upper and lower limits are the values at which the divergence from the average value becomes statistically significant (P = 0.05)

dividing the OBDs by the total available bed-days (ABDs); and the average length of stay can be determined by dividing the OBDs by the number of discharges. (The total available bed-days is simply the number of beds installed multiplied by 365; for purposes of the assessment presented here, the sum total of the available bed-days was not reduced by the number of bed-days set aside for bed disinfection, bed repair, emergencies, or other circumstances that typically reduce the number of beds actually available by something on the order of 5 to 15%.)

Because the number of beds actually installed for patient care *(5,6)* tends to remain constant during periods such as one year, productivity tends to be determined by the number of discharges. This productivity, of course, depends on the percentage of beds occupied and upon how many days the individual patients occupy beds—which depends in turn on the diseases being

treated and upon hospital policies regarding specific clinical standards.

One should not overlook the fact that changes in productivity can also be due to changes in the number of beds; and when such changes occur the fact should certainly be noted. However, an increase in the number of beds generally involves considerable financial investment and a change in the size of the hospital or inauguration or enlargement of a hospital service; it is thus a relatively infrequent event. Similarly, a significant reduction in the number of beds generally involves such things as eliminating or reducing a service, and this is an even rarer event. Periodic fluctuations in the reported number of beds call into question the hospital's actual size and even the effective size of the operating service or ward involved.

Results

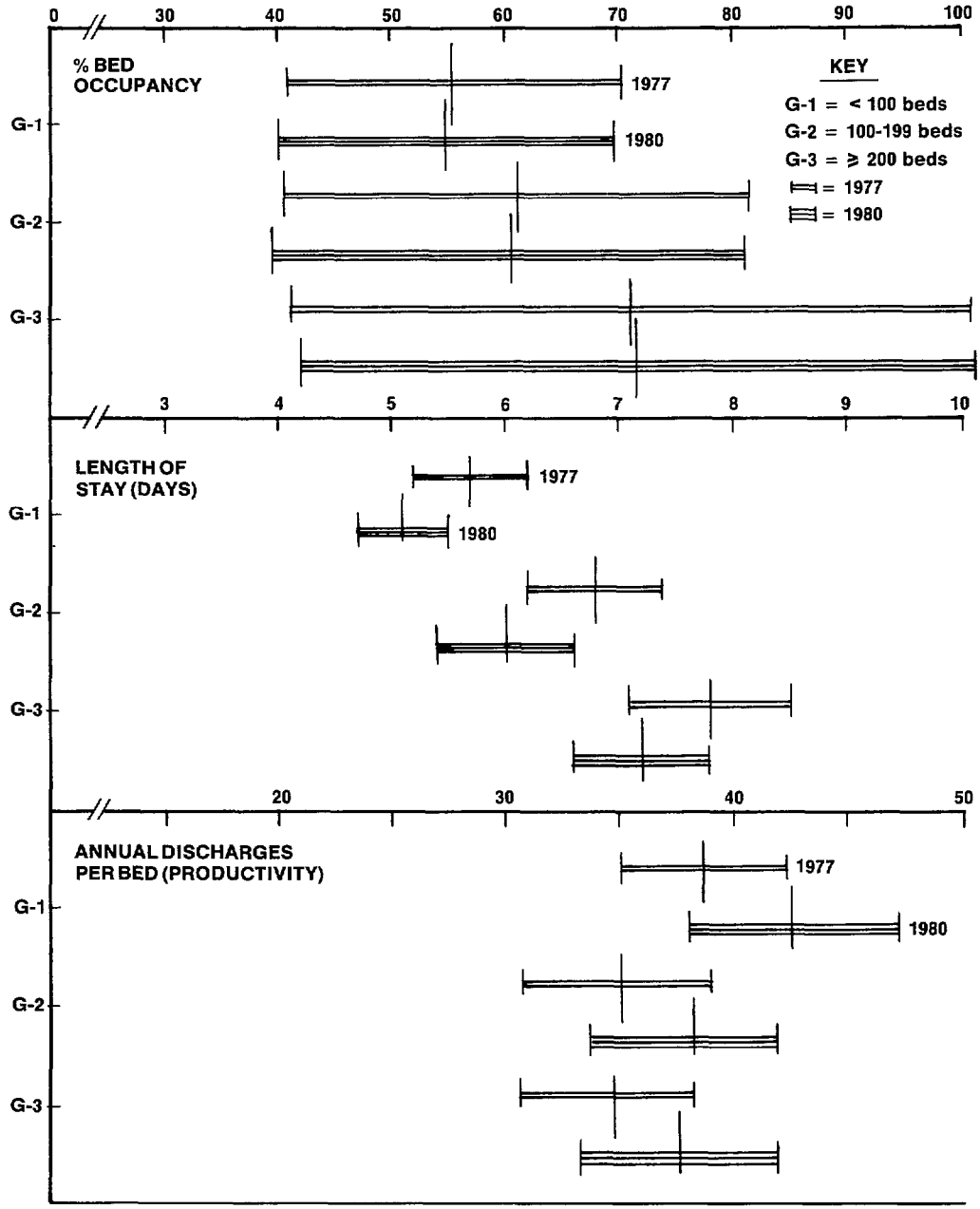
The data displayed in Table 1 and Figure 2 clearly demonstrate that the percentage bed occupancy and the average length of stay at the hospitals surveyed were associated with hospital size (as reflected in the number of beds). Thus, the small hospitals (those with less than 100 beds) tended to have the lowest bed occupancy rates and the shortest average stays in both 1977 and 1980; middle-size institutions (with 100–199 beds) tended to have intermediate bed occupancy rates and average stays; and large hospitals (with 200 beds or more) tended to have the highest bed occupancy rates and longest average stays. Similar but less marked differences are evident between the bed turnover (productivity) of the small hospitals and that of intermediate and large ones, with the productivity rates at the small hospitals tending to be somewhat higher. All this shows that if these regional hospitals' quantitative performances are to be assessed on a comparative basis, at least three averages (one each for small, medium, and large hospitals) should be used in order to avoid decision-making errors—such as those that might occur, for example, if marked differences in the average length of stay at large hospitals as compared to small ones were not considered.

The average bed occupancy and discharge rates found for each of these three groups of hospitals in 1977 and 1980 (see Table 1) were used to define the borders of sectors 1, 2, 3, and 4 on the appropriate charts (Figures 3a through 3f). In addition, 95% confidence limits—beyond which there was 95% confidence of an actual departure from the norm—were calculated for each variable, group of hospitals, and year (see Table 1), and these limits were drawn in on the charts.

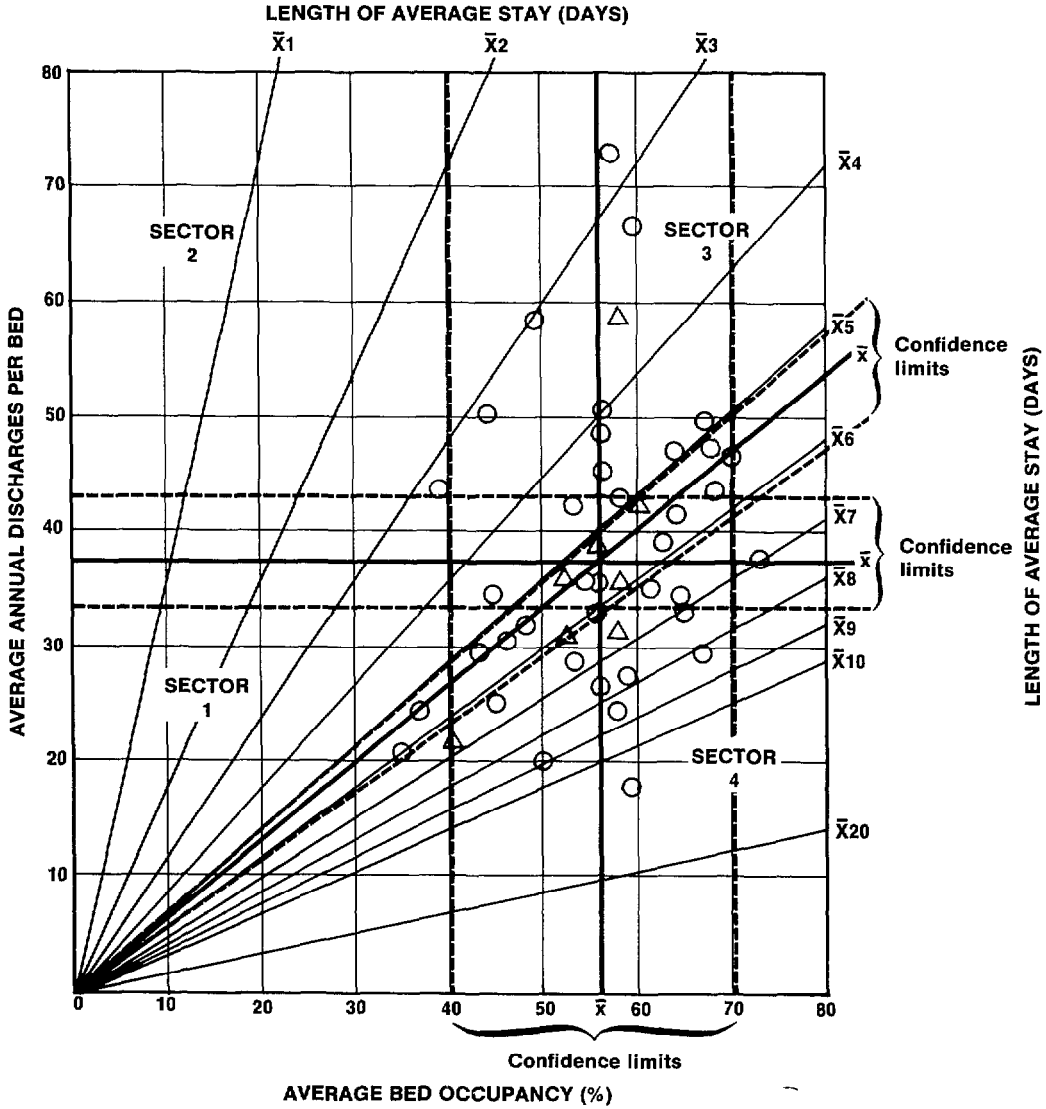
Each hospital studied was then located at the appropriate points on the 1977 and 1980 charts dealing with its group, triangles being used to show hospitals in the survey sample that were selected for in-depth study of administrative and financial data.

This graphic presentation enables administrators and other interested personnel to see at a glance how their hospital is performing within the group as a whole. Specifically, it can be seen if the hospital is in Sector 1 (the low-performance sector), and also whether the hospital is fairly close to the average values for its group, or whether it departs significantly (beyond the 95% confidence limits) from normal values. In cases where the hospital's shortcomings appear significant, it is then possible to examine the causes of these shortcom-

FIGURE 2. A chart showing the influence of hospital size upon bed occupancy rates, productivity, and length of stay at 73 of Colombia's regional hospitals in 1977 and 1980. In each case a point indicated by the vertical midline shows the average value, while the horizontal lines show the range of values up to the upper and lower 95% confidence limits.

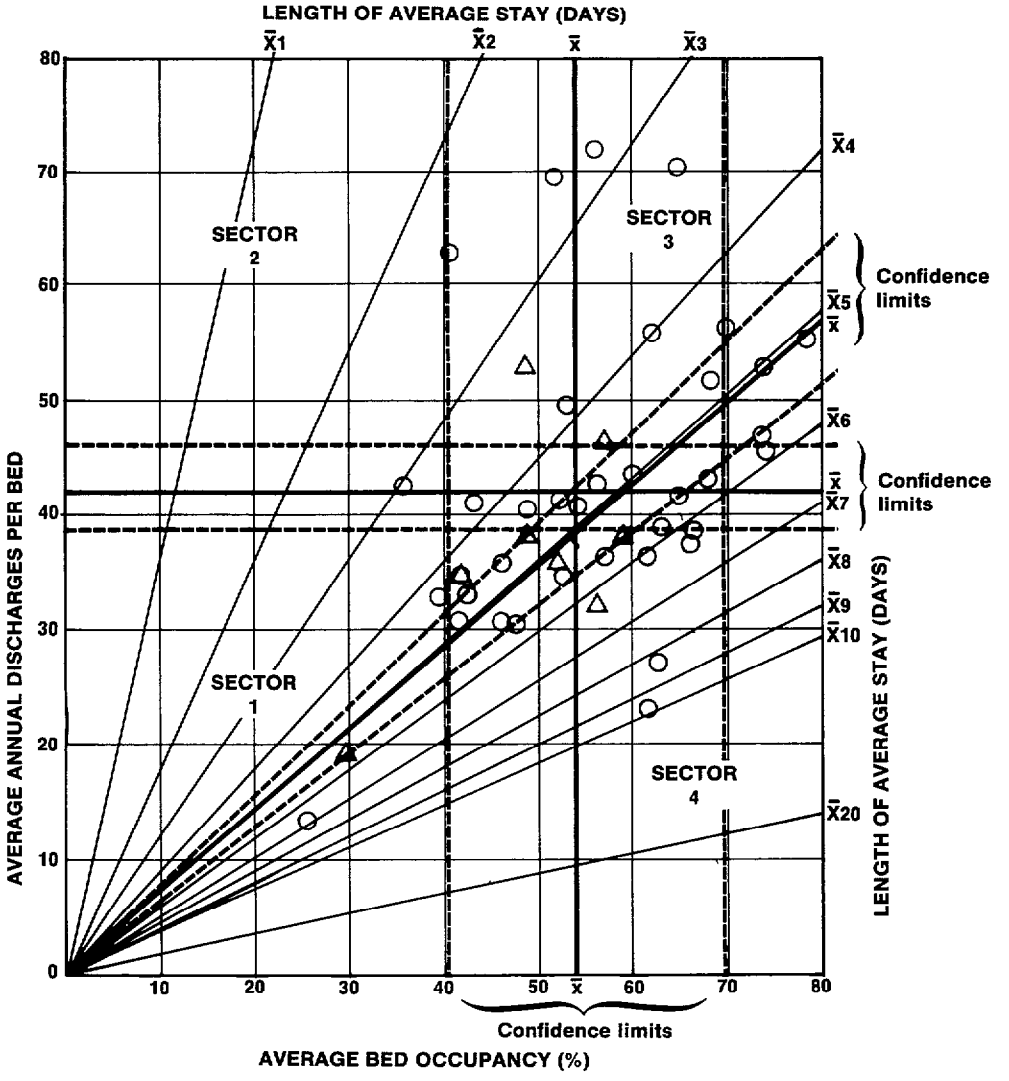


FIGURES 3a through 3f. These charts rate the 1977 and 1980 performance of small (< 100 beds), medium (100–199 beds), and large (≥ 200 beds) regional Colombian hospitals in terms of average bed occupancy, average annual numbers of discharges per bed (productivity), and average length of stay. The lines to either side of these averages show 95% confidence limits. The circles and triangles show the hospitals covered, the triangles designating those where an in-depth study of administrative and financial data was conducted.



3a. Small regional hospitals (< 100 beds), 1977.

Figure 3—*continued*

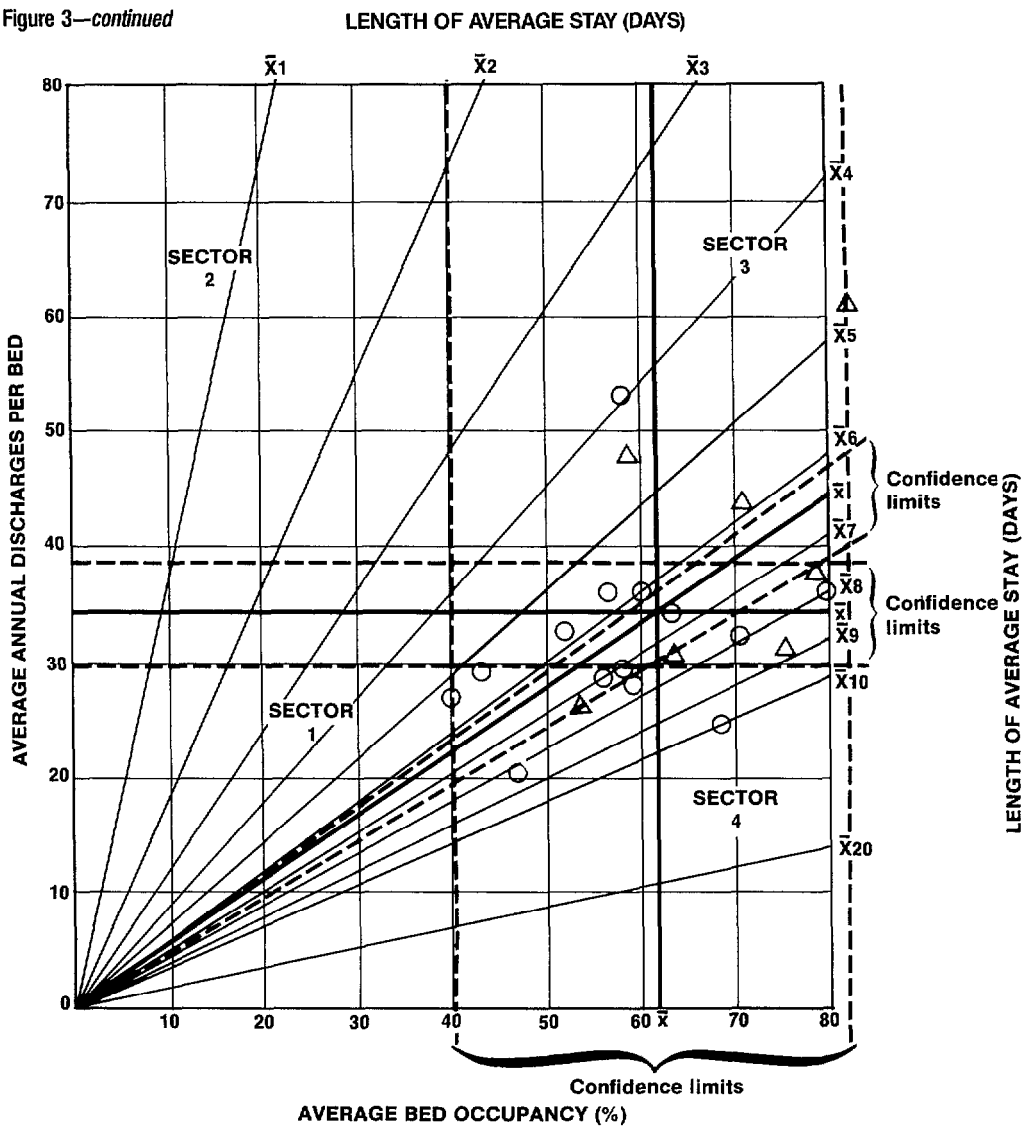


3b. Small regional hospitals (< 100 beds), 1980.

ings, devise strategies for improving performance, evaluate performance relative to the performance of similar institutions elsewhere, compare performance at one time with that of another, and examine possible trends and changes.

It is also possible to get a worthwhile overview of changes in hospital performance nationwide. Table 2, taking data used in the six charts, shows the performance of all the regional hospitals studied for 1977 and 1980, grouping the hospitals according to size and the sector of the chart where they were

Figure 3—*continued*

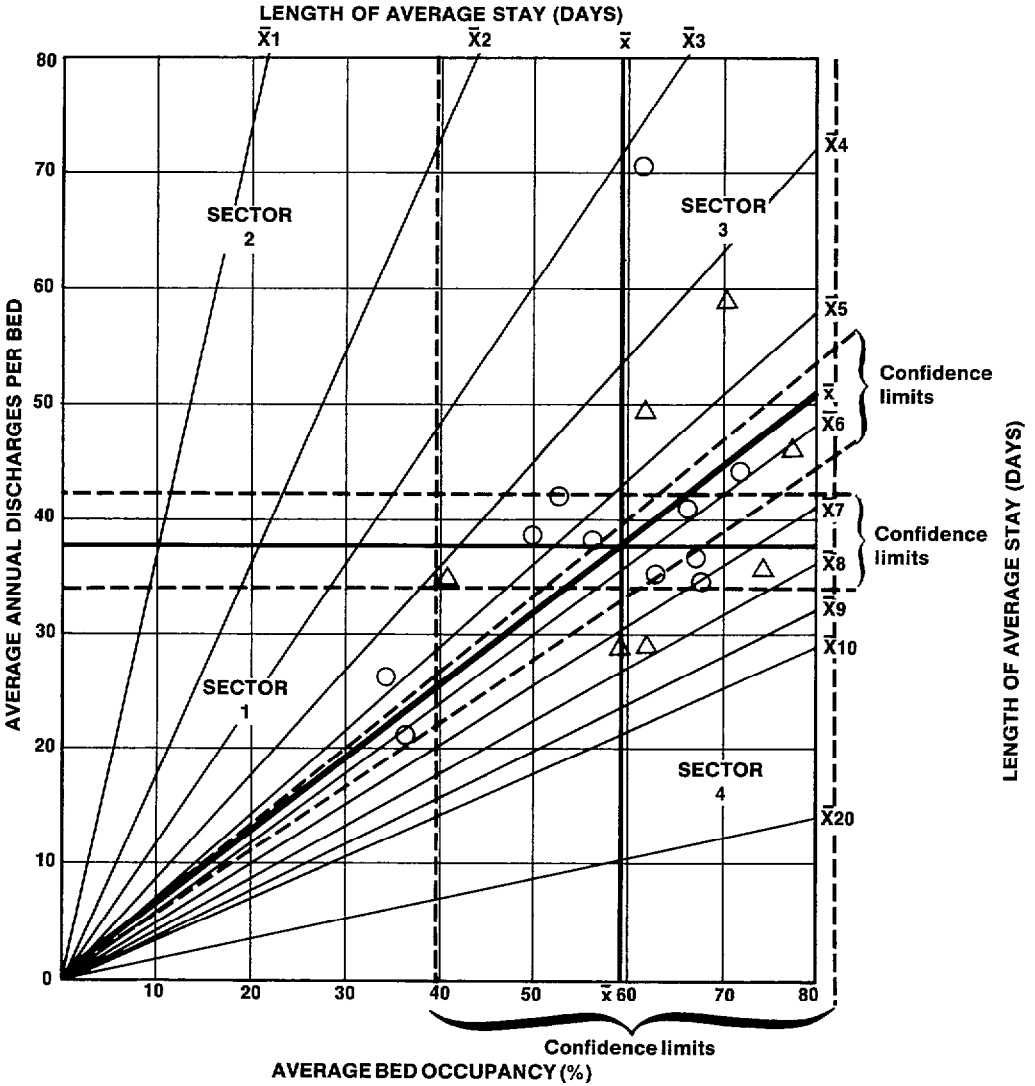


3c. Middle-size regional hospitals (100–199 beds), 1977.

placed. The data indicate little change in the numbers of hospitals in Sector 1 (the low-performance sector) between 1977 and 1980. That is, the numbers of small and large hospitals remained the same; and while the number of medium-size hospitals appeared to fall by four, only one of these four hospitals moved into another sector, the other three being eliminated from consideration in 1980 because of erroneous data.[2]

[2] A fringe benefit of these charts is that they tend to point up erroneous data, because such data commonly make it impossible to find the intersection of the charted variables. (There have been occasions when productivity or bed occupancy was artificially inflated by reducing the number of beds.)

Figure 3—*continued*

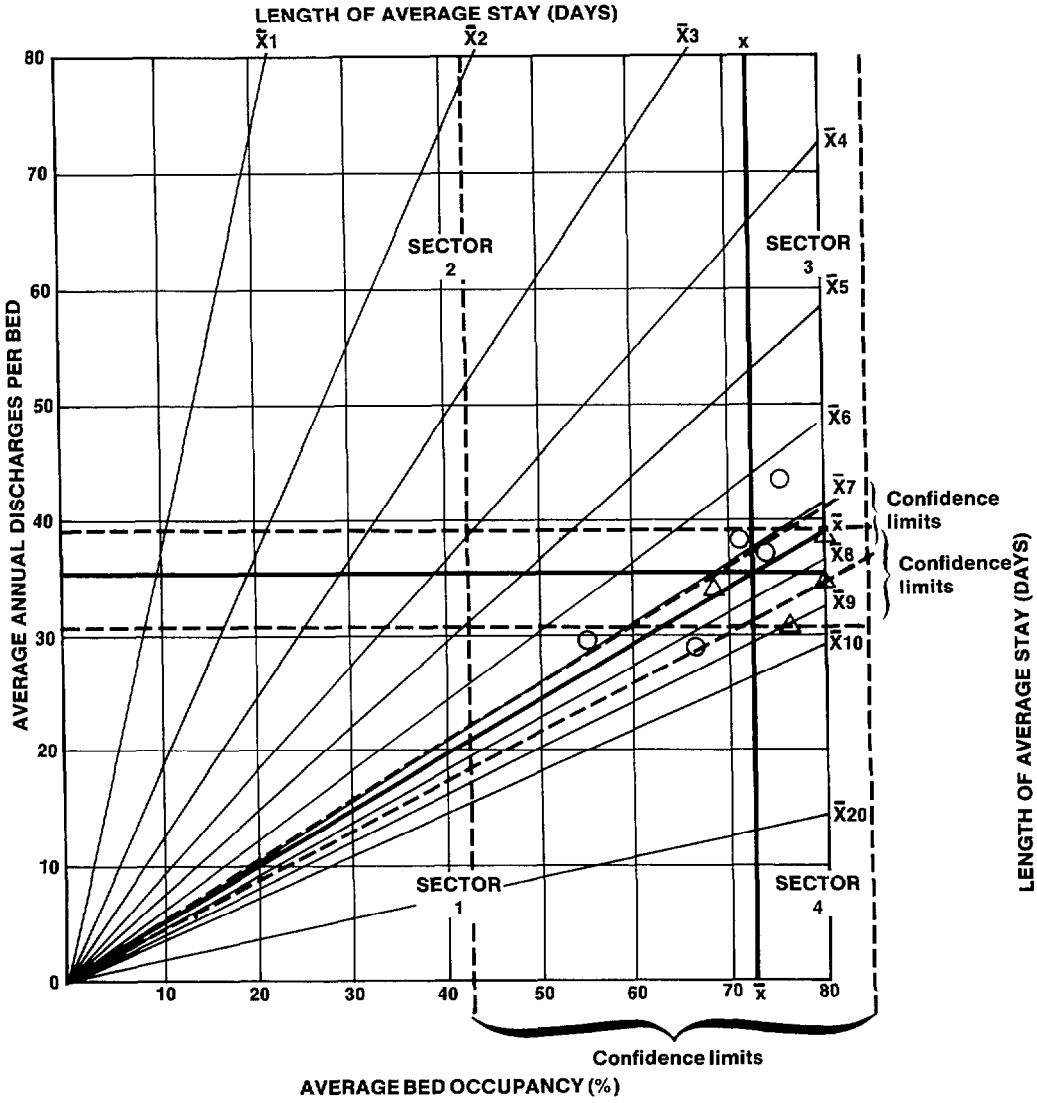


3d. Middle-size regional hospitals (100–199 beds), 1980.

Another noteworthy point is that charts 3b and 3d each show two hospitals in Sector 1 that were markedly separated from the others in their groups. This circumstance should obviously be of concern to the hospital administrators involved.

Because each sector boundary on the charts is derived from average values, one would not expect general improvements to appear as movements from one sector to another, but rather as general movements toward higher rates of bed occupancy and productivity. On this latter basis, the quantitative performance of Colombia's regional hospitals

Figure 3—*continued*

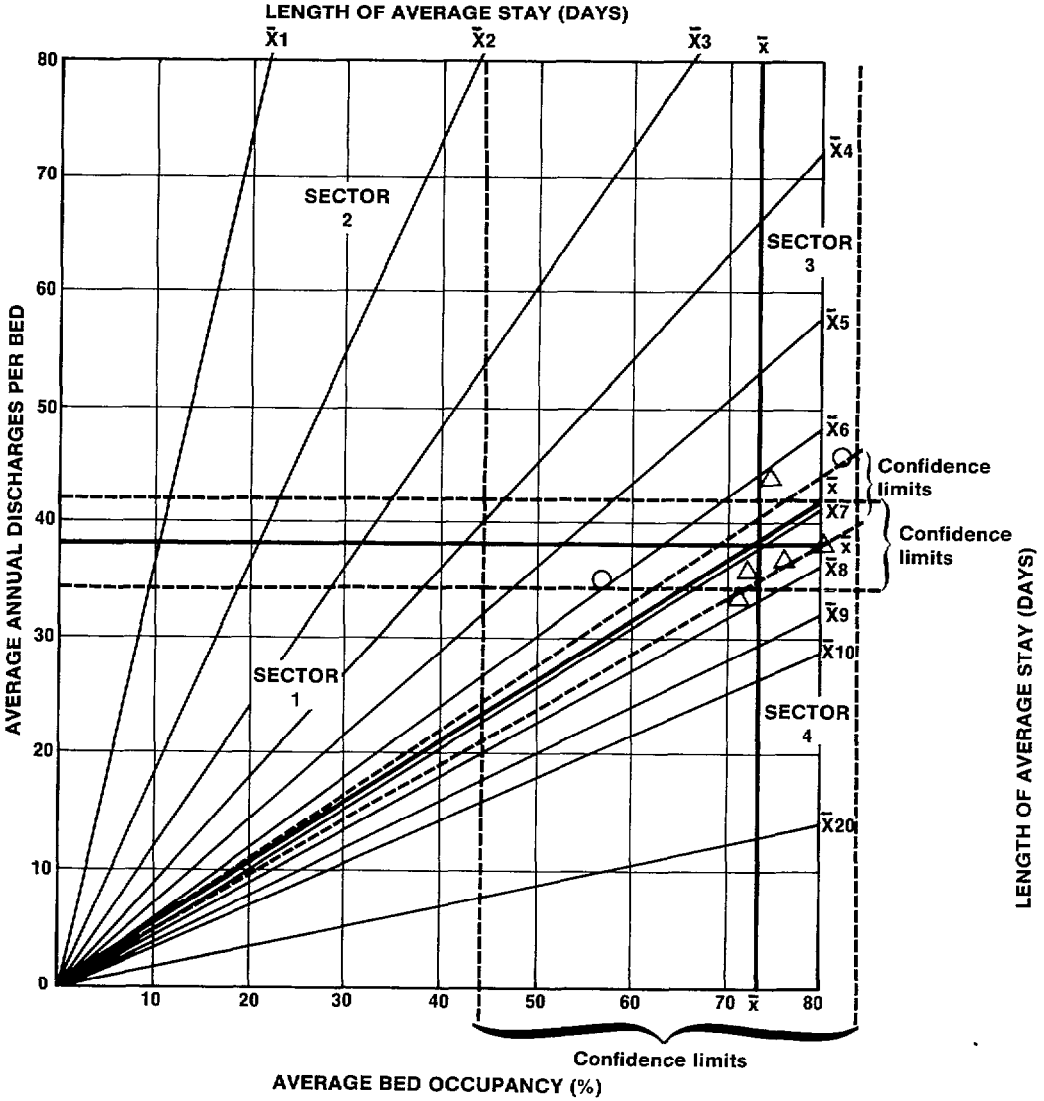


3e. Large regional hospitals (≥200 beds), 1977.

in 1977–1980 can be described as positive; obviously, however, there is still room for substantial improvement.

Table 3 indicates the 1977–1980 performance of Colombia's regional hospitals with fewer than 100 beds, grouped according to regional (multidepartmental) subdivisions. The boundaries of each major region and the departments within it are shown in Figure 4. These data show that in Region A the values involved remained about the same. In Region B both bed occupancy and length of stay declined while pro-

Figure 3—*continued*



3f. Large regional hospitals (≥ 200 beds), 1980.

ductivity improved. In Region C productivity improved slightly. In Region D bed occupancy declined, length of stay declined, and productivity improved slightly. And in Region E bed occupancy increased sharply, length of stay declined, and productivity improved sharply.

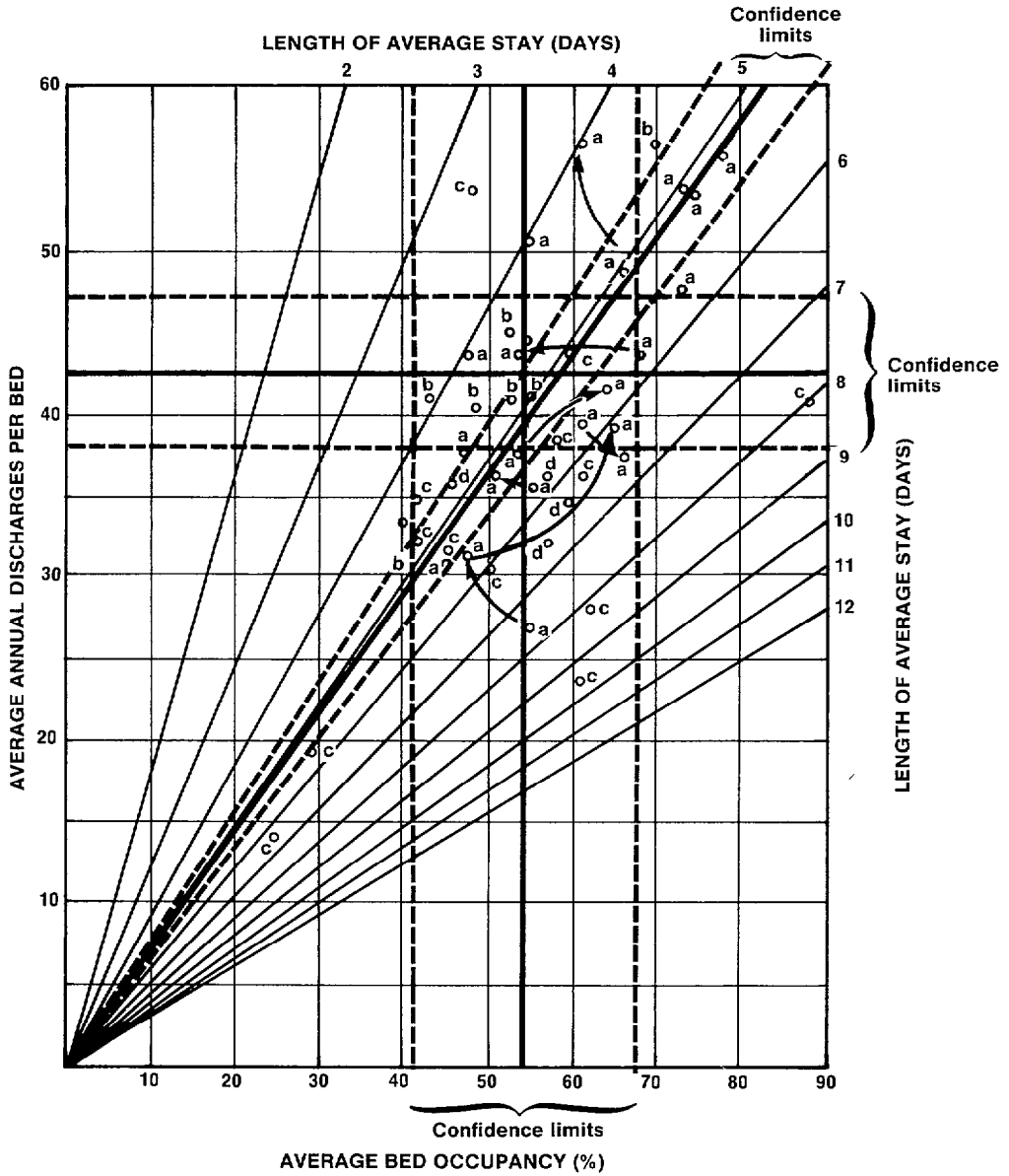
Relative to the other regions, Region C had an unusually low bed turnover ratio as a result of long hospital stays—a situation implying unwarranted stays, a relatively small proportion of obstetric stays (deliveries), or a combination

FIGURE 4. A map of Colombia showing the grouping of individual departments into regions a through e.

of these and other factors. Region E showed the highest productivity of any region in 1977, and improved its showing markedly in 1980 as a result of improved bed utilization and shortened stays. Overall, the country's regional hospitals with less than 100 beds improved their productivity in the 1977–1980 period; and since there was no average improvement in the bed occupancy rate, this improvement can be attributed almost entirely to shorter average stays.

Regarding the changes experienced by individual hospitals, Figure 5 shows the position of each small Region A hospital in 1977 and 1980, together with the positions of all the other small

FIGURE 5. Quantitative performance of small (< 100 bed) regional hospitals in 1980 and changes in performance of small Region A hospitals between 1977 and 1980. For each Region A hospital, an arrow is drawn from its 1977 position to its 1980 position.



regional hospitals in 1980. The arrows in the figure show how the situation at each Region A hospital changed from 1977 to 1980. This chart makes the magnitude and direction of change in each performance indicator readily apparent, permits the principal change vector to be followed over time for each hospital, and provides the basis for devising policy seeking to correct weaknesses in the institution's quantitative performance. The usefulness of examining all three charted variables together is shown by the fact that in some cases where productivity was improved or maintained and the average stay was shortened, these gains were offset by a reduced bed occupancy rate; whereas in other cases the average hospital stay remained fairly constant, the bed occupancy rate increased, and meaningful gains in productivity were made.

Concluding Remarks

The methodology illustrated here is designed to augment various earlier approaches for working with the three traditional indicators covered *(1,7)*. In the past, some administrators believed there was an association between hospital size and relative efficiency. For example, a 1981 PAHO publication *(1)* refers to this belief, points to the assumption that an average stay of seven to nine days and occupancy rates of 70% to 80% were relative measures of optimum efficiency, and that size, to a certain extent, determined both the occupancy rate and the average length of inpatient stays. This publication also asserts that the turnover (discharges per bed) rate is sensitive to changes in the occupancy rate and in the length of inpatient stays. The work concludes that if a minimum acceptable turnover rate had to be established for Latin America, an occupancy rate of 60% and an average stay of nine days might be selected, since nearly two-thirds of the countries with data available had reached those levels.

Another work, this one by N. E. Massabot published in 1978 *(8)*, proposed using graphs to define the limits of the ideal range of bed utilization. This proposed method, like the one described here, charted productivity, length of stay, and bed occupancy. However, the procedure required uniform data from each facility studied, and the manner in which the graphs were to be constructed was not described.

The procedure described in this article seeks to employ a modification of Massabot's method to provide a tool for assessing hospital performance. The procedure is also designed to emphasize the contribution that hospital size makes to determining certain performance levels. For while it is recognized that small hospitals tend to involve relatively short average stays and low occupancy rates, it is sometimes not recognized that the performance of small, medium, and large hospitals should not be compared using the same set of standards.

Acknowledgments

The author wishes to thank statistician Reynaldo Carvajal for his assistance in confirming the statistical validity of various features of the method described here, and also the directors of Colombia's regional hospitals for supplying data about their institutions.

Summary

Various indicators can be used to gauge a hospital's quantitative performance, among them the average percentage of beds occupied, the average number of discharges per bed over a given period, and the average length of a hospital stay. These indicators are usually examined in isolation for lack of a convenient way of examining them together. This article describes a method used in Colombia to combine them so as to get an overview of hospital performance not readily obtainable by other means.

The principal device employed is a chart in which bed occupancy is measured along one axis, productivity (the number of discharges per bed) is measured along the other, and the average length of stay is indicated by a series of straight lines radiating outward from the origin. This chart is divided into four sectors, one indicating good performance (high bed occupancy and high productivity), another pointing to poor performance (low bed occupancy and productivity), and the other two suggesting intermediate situations. The chart also indicates when there is a 95% probability that a given hospital's apparent performance represents an actual departure from the norm. However, because of marked differences in the performance data from hospitals of different sizes, it has been found desirable to group hospitals according to size (in terms of the number of beds installed) and to assess the performance of individual hospitals relative to other hospitals in the same group.

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