Forecasting The Need For Hospital Beds: A Quantitative Methodology

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HEALTH PLANNING requires grappling with the rationing of scarce resources. In recognition of this concept, the National Health Planning and Resources Development Act of 1974 (Public Law 93-641) strengthened the links connecting health planning agencies with the decision-making apparatus for certification of need programs.

A principal objective of certification of need is to control the supply of health care resources and perhaps thereby to improve the distribution of health care services and to stem the rising tide of costs. Since hospital beds represent a major component of health care costs, methods used to forecast the need for hospital beds are a central focus of certification of need programs (*1*).

The essential dilemma of forecasting, particularly when change is sought, is to make constructive use of experience without becoming captive of the past. The Hill-Burton formula used existing demand without regard for its origins or appropriateness. Knowing now that supply in the health sector creates demand, health planners are developing normative standards of need based on society's experience and on the best current knowledge of where change is possible. The methodology described in this paper differs significantly from the Hill-Burton approach. It deliberately affords a critical reappraisal of current performance and allows the consideration of substantially changed alternative futures.

The methodology evolved in the context of the Massachusetts certification of need program (*2,3*). It applies generally to the allocation of beds in acute-care hospitals and can be used by State regulatory or planning agencies, health systems agencies, and individual hospitals. The method was devised to address the problem of how to make fair and specific quantitative decisions concerning number of beds, volume of services, or expenditure of dollars with limited information. By proceeding systematically and exposing the assumptions implicit in each step, the method seeks to build toward the identification and resolution of policy issues needing attention.

Although the methodology can be used simply to project the past, it is also compatible with vigorous regulatory and planning actions based on the following assumptions:

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• An overabundance of hospital beds is a principal cause of the inadequate performance of the health care delivery system.

• Constraining the development of this expensive and overused resource is a necessary (though hardly sufficient) step toward a more equitable and efficient system (3).

• An overestimate of need has costly long-range implications and is far more serious an error than an underestimate. The effects of certificate of need decisions are felt slowly (2), and ample lag time remains for adjustments if decisions have been overly restrictive; but once a bed is approved, it represents a lifetime cost of some $1.8 million. (This figure is based on a mean per diem cost of $152, calculated by Blue Cross of Massachusetts for 1975, and an average lifespan of 30 years).

• Certification of need is an implicit appropriation process effectively obligating both government and private programs for the capital and operating costs of the projects that are approved.

• Efforts to change the distribution of health care resources will succeed only if reasons for the change are rational and defensible, and the logic underlying decisions is open to public discussion.

Overview of the Methodology

Organization. The methodology analyzes three questions in sequence, each question progressively less easily quantified: How many beds will be needed at the index hospital over a timespan of at least 10 years (part I)? Are there surplus beds available in neighboring hospitals (part II)? Are there other relevant issues (part III)?

Part I forecasts the need for beds at the index hospital, after first determining the current situation. Four variables are analyzed: inpatient days per person per year; average length of stay; occupancy rate; and population served, all age-specific by clinical service. These can be set by historical precedent or by policy forecast, depending on the objectives. If the goal is to alter the distribution of health care resources, future need at the index hospital is considered in light of health care policy. The past is not projected directly into the future. Instead it is used as a base for testing assumptions about what the future should hold: how patient origin and destination patterns and population-based utilization might change, how management and use of hospitals might be improved, and how such changes might affect the need for beds, if some of the slack in the system could be tightened. This methodology was designed specifically to allow the introduction of assumptions about patterns of hospital use in years to come.

Part II analyzes whether surplus beds in neighboring hospitals could serve as a reserve for the index hospital in times of peak demand. The waters here are murkier, and quantification is more hazardous. Are there neighboring facilities with surplus beds? Can these beds reasonably be expected to substitute for some beds in the index hospital? By what criteria? How many beds can be considered available to the index hospital?

Part III explores other policy issues bearing on the need for beds in the index facility. These issues require weighing and balancing of questions not easily quantified. Is hospital expansion ever justified primarily to enable a community to attract and hold qualified physicians? Is it ever warranted for other reasons independent of the need for the facility, perhaps as part of an effort to make an area more attractive to industry by improving the medical resources available? Should exceptions be made for denominational and specialized hospitals serving a limited population? The more complex and inevitably more subjective questions are held for this final step where they can be debated openly, and their impact on the estimate of need can be seen.

Information required. The methodology requires only ordinary hospital data and simple mathematical operations. Parts I and II build on patient origin and destination data. Origin data show the cities of residence of all patients admitted to the hospital. For example, of 5,622 admissions to Leonard Morse Hospital in 1973, 42 percent were Natick residents, 10 percent were Framingham residents, and so on. Destination data show how many residents of a given area (city, town, zip code, or census tract), and what percentage of all residents hospitalized were admitted to which hospitals. For example, of 4,481 Natick residents who were hospitalized in 1971, 65 percent went to Leonard Morse Hospital, 11 percent went to Framingham Union Hospital, and so on. Patient origin data are required from all hospitals serving geographic areas that overlap the area the index hospital serves. They should cover a full year, but need not be absolutely current. Geographic patterns of hospitalization shift gradually unless a dramatic change occurs in the constellation of services available or in the demographic composition of an area. Studies of patient origin and destination can be done either on a sample of admissions annually or semiannually, or on all admissions at intervals of about 5 years. Ideally, these data should be specific for each major service (medical-surgical, obstetrics, and pediatrics) although, at least for the medical-surgical service, undifferentiated data appear to be an acceptable substitute. All other data—admissions, patient days, and average length of stay, as well as population figures—must be related specifically to the service at issue. For the medical-surgical service, the methodology calls for this information in two age categories: 15–64 years and over 65 years.

Except for the hospital destination data, which require an aggregation by area or State of records from individual hospitals, the required data are routinely accumulated by well-run institutions for internal planning. The methodology combines, summarizes, and distills this information.

The derivation of service populations for part I requires population data for each city in the hospital's service area. The data must be broken down into age and sex categories related to hospital use: 0–15 years for pediatrics; women 15–44 years for obstetrics; 15–64 years and 65 years and over for the medical-surgical service. The future service populations are projections, which appear as part of the analysis and are thereby open to public challenge. Exposing the data on which the calculations rest increases the likelihood that errors or mistaken assumptions will be corrected in the review process, for example, by regional or local groups who have a closer view than the State has of population changes in their areas.

Illustrative case studies. In refining and testing the methodology, we have applied it in retrospect to several representative certificate of need applications acted on by the Massachusetts Public Health Council. Two of those cases are presented for illustration, with three caveats: In both cases the certificate of need decisions were made before the full development of the methodology, all of the information used comes from public records, and the specific details of the various hospitals' operations have doubtless changed substantially since the applications for certificates of need were filed.

The methodology is summarized in figure 1. Its application in one of the cases, the medical-surgical service of Leonard Morse Hospital, is shown step-by-step in tables 1–9, and a summary of the other case, Somerville Hospital, which has only a medical-surgical service, is given in figure 2. The tables, which are keyed to the steps, include all formulas needed for the computations and can be used as worksheets.

The sources of the data in the tables were as follows: patient origin data, from admission statistics of the medical surgical service of Leonard Morse Hospital for the year ended September 30, 1973; patient destination data (which are for all hospital services combined for the year ended September 30, 1971),

Figure 1. Step-by-step summary of the methodology for forecasting the need for hospital beds

Part I. Need for Beds in Index Hospital

Step 1. Define service populations, current and future
- a. Determine primary service area
- b. Derive service population, current and future
- c. Establish number of elderly (65 and older), current and future

Step 2. Compute current utilization
- a. Average length of stay: elderly, nonelderly, and total
- b. Patient days per person per year: elderly, nonelderly, and total
- c. Occupancy rate
- d. Current demand for beds (existing number)

Step 3. Compute future utilization and need
- a. Estimate future admissions: elderly and nonelderly
- b. Establish policy on average length of stay: elderly and nonelderly
- c. Calculate patient days: elderly and nonelderly
- d. Combine elderly and nonelderly to obtain total patient days and total admissions; compute average length of stay and patient days per person from total admissions and patient days
- e. Establish policy standard for occupancy rate
- f. Calculate future need for beds

***Result:* Initial estimate of bed need**

Part II. Other Available Beds

Step 4. a. Identify other relevant hospitals
- b. Calculate surplus beds

Step 5. Determine index hospital's share of the surplus
- a. Compute the percentage of each hospital's total admissions from the index hospital's primary service area
- b. Multiply each hospital's daily number of surplus beds by that percentage, and compute total for all the hospitals combined, to establish minimum share
- c. Assign a share ($\geqq$ minimum share and $\leqq$ total surplus)

Step 6. Project current surplus (index hospital's share) into the future, using inverse ratio of current beds to future need (steps 2d and 3f).

Step 7. Subtract surplus beds available (step 6) from initial bed need (part I)

***Result:* Corrected estimate of bed need**

Part III. Other Relevant Issues

***Result:* Final determination of bed need**

from a study by the Massachusetts Department of Public Health; population estimates, both baseline and 1985 projections, from the Department of Sociology, University of Massachusetts; and hospital utilization information (admissions, patient days, and mean daily operating capacity), from 1973 hospital statistical reports filed with the Massachusetts Department of Public Health.

Figure 2. Calculation of beds needed in the Somerville Hospital

Part I. Need For Beds in Index Hospital

Step 1. Service populations:

	Age group (years)		
	15-64	65 and over	15 and over
Current [1]	19,214	2,692	21,906
Future	16,949	2,574	19,523

Step 2. Current utilization and demand:

	Age group (years)		
	15-64	65 and over	15 and over
Admissions	2,945	1,542	4,487
Patient days	20,172	19,636	39,808
Average length of stay (days)	6.85	12.73	8.87
Patient days per person per year	1.05	7.29	1.82
Occupancy rate			0.78
Current demand for beds (existing number)			140

Step 3. Future need:

	Age group (years)		
	15-64	65 and over	15 and over
Admissions	2,338	1,622	3,960
Patient days	16,366	17,031	33,397
Average length of stay (days)	7.0	10.5	8.43
Patient days per person per year	0.97	6.62	1.71
Occupancy rate			0.78
Beds needed (initial estimate)			104

Part II. Other Available Beds

Step 4. Surplus beds in 7 relevant hospitals	131
Step 5. Index hospital's portion:	
Minimum share	61
Assigned portion	105
Step 6. Future surplus	176
Index hospital's share	141
Step 7. Corrected estimate of need for beds	−37

Part III. Other Relevant Issues

Final determination of need (July 9, 1974): 134 beds

[1] 1970 population; 1973 hospital data.

Somerville Hospital is a community hospital located in Somerville, Mass., adjacent to Cambridge and Boston with their wealth of medical resources. The greater Boston area has the highest bed-to-population ratio in the State, 11.72 beds per 1,000 population (*4*). Moreover, the populations of Somerville and neighboring cities are declining. In December 1971, Somerville Hospital filed for a determination of need to renovate and expand its outdated facility. At the time, the hospital was licensed to operate 140 medical-surgical beds. It requested 160 medical-surgical beds, and in July 1974 it was awarded 134. The Somerville case illustrates the application of the methodology to a hospital situated in an area with overabundant hospital beds. It was the dilemma of the Somerville case that gave the immediate impetus to the development of this methodology (*5*).

Leonard Morse Hospital is a general hospital in Natick, Mass., a growing suburban community 23 miles west of Boston. This area had a relatively modest ratio of 3.06 medical-surgical beds per 1,000 population in 1973 (*4*). In May 1974, Leonard Morse Hospital filed an application for a determination of need for a "substantial change in service" and an increase from 159 to 201 medical-surgical beds (including beds for intensive care.) Services other than the medical-surgical were at issue, but they are not discussed here because of their irrelevance in illustrating the methodology. Leonard Morse Hospital was awarded the 42 additional medical-surgical beds requested.

Establishing Need at the Index Hospital

Part I of the methodology deals exclusively with the index hospital, that is, the hospital applying for a certificate of need or engaged in planning. Step 1 involves calculating the current and projected populations served by the index hospital (or by the particular inpatient service under study). For the medical-surgical service, the number of persons aged 65 and older in both the current and projected populations is computed so that independent assumptions can be made about this group, whose use of medical-surgical beds tends to be disproportionately high. In step 2, average length of stay and patient days per person per year, both service-specific, are computed.

The redundancy is deliberate. Patient days are a function of length of stay and admissions, but all three measures are computed for comparison with the projections made in step 3. Step 3 projects use and provides an estimate of the future need for beds.

Step 1. The area served by the index hospital is identified from the patient origin data as previously defined. These data suggest the index hospital's primary service area, which we define as comprising the cities and towns from which the hospital draws a major portion (approximately 80 to 90 percent) of its patients (step 1a, table 1).

Defining the term "major portion" cannot be entirely objective, but normally the definition has little impact on the final estimate of need. The cutoff point for the primary service area is always inconsequential in deriving the population served by the index hospital because the calculation corrects for the balance of patients who reside outside this area. However, the cutoff point can assume importance in step 5, part II, in determining the index hospital's share of the surplus beds in other hospitals. The primary service area is the basis for this determination, but the cutoff point influences the outcome only if there is an anomaly to cause a distortion, for example, if the neighboring hospitals have a great many surplus beds or if some of the cities are substantially larger than others.

The Somerville Hospital illustrates such a case. It drew 76 percent of its patients from Somerville, 5 percent each from Medford and Cambridge, 3 percent from Arlington, and 2 percent from Boston. Equally strong cases can be made for considering only Somerville, for including the next four cities, or for including only the next three cities, as we did. We calculated step 5 using the three possible alternatives and asked which of the solutions looked most reasonable. Somerville Hospital's percentage of the available surplus would have been smallest if only the city of Somerville had been included in the primary service area and largest if all four cities had been included. The difference was considerable, because these cities, particularly Cambridge and Boston, are populous and send many residents to the other relevant hospitals. The judgment required here is one of many factors contributing to the uncertainties considered in part III of the methodology.

Defining a primary service area for Leonard Morse Hospital was easier. Nine cities together accounted for the origins of 79 percent of the hospital's medical-surgical admissions in 1973, and the other cities each accounted for less than 1.5 percent of the remaining patients.

Next, the index hospital's percentage of each city's total hospital admissions is multiplied by the current population of each city to derive the current population in that city served by the index hospital (step 1b, table 2). The sum of these service population figures, plus a correction for the balance of the index hospital's admissions from outside the primary service area, is the index hospital's current service population.

Before the future service population is calculated, the hospital's share of the admissions from any of the cities of patient origin can be adjusted to take into account expected changes. A hospital's share of admissions might be affected by, for example, a change in patterns of physician referral, introduction of a new ambulatory care service, expansion or contraction of a competing hospital, or changes in the style of practice—perhaps in a maternity service—causing consumers to change their preference of one facility over another. The effect of such anticipated changes on the index hospital's share of the "market" is estimated, and the hospital's percentage of each city's total admissions for the future is adjusted accordingly. No adjustment appeared warranted in our example, so none was made.

There might also be evidence that one hospital has an inappropriately high rate of admissions relative to the other institutions serving the same area. Evidence of this situation might be gleaned from such indicators as the number of admissions per bed or per physician by specialty, the pattern of procedures done in the facility, or information available through licensure and utilization review programs. To avoid rewarding the overadmitting hospital by carrying its inflated share of the market into the future, it is necessary to reduce for the future the current market share percentages.

After the market share adjustment is made, the

Table 1. Step 1a: Primary service area of the medical-surgical service, Leonard Morse Hospital

	Admissions, 1972–73		
Origin of patients	*Number*	*Percent*	*Cumulative percent*
Natick	2,379	42.32	42.32
Framingham	590	10.49	52.81
Wayland	291	5.20	58.01
Holliston	278	4.94	62.95
Medfield	246	4.38	67.33
Millis	211	3.75	71.08
Sherborn	168	2.99	77.00
Wellesley	165	2.93	74.01
Dover	138	2.45	79.45
Other	1,156	20.56	100.01
Total	5,622	100.01	100.01

NOTE: The total number of admissions here differs from the total appearing in table 4 because of discrepancies in reporting.

Table 2. Step 1b; Derived current (1970) and future (1985) service populations for the medical-surgical service, Leonard Morse Hospital

(A) Origin of patients	(B) Admissions to hospital	(C) Percent of city's total admissions	(D) Current adult [1] population	(E) Current service population [2]	(F) Future adult [1] population	(G) Future percent of market	(H) Future service population [3]
Natick	2,379	65	21,349	13,877	24,110	65	15,672
Farmingham ..	590	9	44,891	4,040	76,054	9	6,845
Wayland	291	27	8,880	2,398	12,493	27	3,373
Holliston	278	20	7,415	1,483	18,326	20	3,665
Medfield	246	26	6,542	1,701	13,932	26	3,622
Millis	211	35	3,647	1,276	5,413	35	1,895
Sherborn	168	43	2,114	909	4,388	43	1,887
Wellesley	165	7	20,826	1,458	20,933	7	1,465
Dover	138	27	3,163	854	5,196	27	1,403
Subtotal	4,466			27,996			39,827
Other	1,156			[4] 7,247			[5] 10,309
Total	5,622			35,243			50,136

[1] Aged 15 years and over.
[2] Column E = [(column C) (10^{-2})] [column D].
[3] Column H = [(column G) (10^{-2})] [column F].
[4] (Other, column E) = [(subtotal, column E) (other, column B)] ÷ (subtotal, column B).
[5] (Other, column H) = [(subtotal, column H) (other, column B)] ÷ (subtotal, column B).

future service population is calculated by multiplying each city's projected 1985 population by the corrected market share percentage.

The number of elderly (aged 65 and over) in the current and future service populations is estimated by multiplying each city's portion of the total derived service population, current and projected, by the percentage of elderly in each city's population, current and projected (step 1c, table 3).

Step 2. The current service populations computed in step 1 and the total annual number of hospital admissions and patient days from hospital records are used to calculate indices of current use (table 4). Average length of stay (step 2a) and patient days per person per year (step 2b) are computed for the elderly and the nonelderly separately and then for the total population 15 years and over. The occupancy rate is computed for the hospital service on the basis of the

Table 3. Step 1c: Estimated number of persons aged 65 years and over in the current (1970) and future (1985) service populations for the medical-surgical service, Leonard Morse Hospital

(A) Origin of patients	(B) Current service population [1]	(C) Current percent elderly in total population	(D) Estimated number elderly in current service population [2]	(E) Future service population [1]	(F) Future percent elderly in total population [3]	(G) Estimated number elderly in future service population [4]
Natick	13,877	8.1	1,124	15,672	10.4	1,630
Framingham .	4,040	8.5	343	6,845	8.3	568
Wayland	2,398	6.0	144	3,373	7.5	253
Holliston ...	1,483	4.9	70	3,665	3.2	117
Medfield	1,701	7.2	122	3,622	3.8	138
Millis	1,276	7.3	93	1,895	8.4	159
Sherborn ...	909	5.9	54	1,887	5.3	100
Wellesley	1,458	10.8	157	1,465	11.3	166
Dover	854	8.3	71	1,403	10.1	142
Other	7,247	[5] 7.4	536	10,309	[6] 7.6	783
Total ...	35,243	...	2,714	50,136	...	4,056

[1] From table 2.
[2] Column D = [column B] [(column C) (10^{-2})].
[3] From population projection study.
[4] Column G = [column E] [(column F) (10^{-2})].
[5] Mean current percentage of elderly in cities constituting the primary service area.
[6] Mean future percentage of elderly in cities constituting the primary service area.

total number of patient days and the existing number of beds (step 2c). Finally, the current demand for beds is calculated from the figure for total patient days and the actual service-specific occupancy rate. (Of course, use of the actual occupancy rate with current patient days is based on the assumption that the number of beds currently "demanded" is simply the number existing, since the formula for occupancy rate is the inverse of the formula for beds. However, this assumption need not be used for the future and, in fact, comparison of present "demand" with the policy assumptions about the future is made in succeeding steps.)

Step 3. The future use of beds is computed separately for the elderly and the nonelderly. In calculating the expected number of admissions (step 3a), the possible effect of expected changes in patterns of medical practice is considered. For our illustrative cases we hypothesized that the rate of admissions for the nonelderly population would decrease 10 percent by 1985 as a result of greater reliance on ambulatory care and that the rate for the elderly would increase 10 percent because of a disproportionate growth of the population aged 75 and over. These percentages are offered simply as examples. The estimates used ought to draw on national, State, and regional comparisions and, more importantly, on the experience of alternative delivery systems (such as prepaid group practices) and on knowledge of the area in which the hospital is situated. Pertinent factors would include current and anticipated availability of long-term and ambulatory care, salient trends in morbidity and mortality, and community variations in hospital use such as those documented by Wennberg (*6*).

Average lengths of stay for the elderly and nonelderly are established by policy (step 3b). The figures used could be statewide norms, although in Massachusetts wide differences between regions complicate the task of setting figures to be applied across the State. In the absence of an established policy, figures may be set for the hospital under study, based on current average length of stay at that and neighboring hospitals and consideration of utilization review activities in the hospital and the area.

In our case studies, the average length of stay for 1985 was set at 7.0 days for the nonelderly and 10.5 days for the elderly. Again these figures were chosen merely for illustration, since the setting of standards is beyond the scope of this paper. The methodology provides a context in which the effects of alternative policy decisions as they are applied to specific cases can be seen.

On the basis of the policy figures, patient days for the elderly and the nonelderly are computed separately (step 3c, table 4). Data for the two groups are then combined to arrive at total admissions, patient days, patient days per person, and average length of stay in 1985 (step 3d).

The age- and service-specific figures projected for patient days per person and average length of stay afford a critical look at the policy decisions made up to this point. If either figure appears unreasonable compared with current rates in the index hospital, the region, the State, the nation, or nontraditional systems of care (such as prepaid group practices), then it is necessary to return to steps 3a and 3b and adjust the policy figures for age-specific admissions and average length of stay.

Next, a policy standard for occupancy rate is established (step 3e). We used a standard of 90 percent

Table 4. Steps 2 and 3: Current (1973) demand and future (1985) need for beds, medical-surgical service, Leonard Morse Hospital

Age group and utilization measure	*Current*	*Future*
15–64 years		
Service population	32,529	46,080
Admissions	[2] 4,031	[3] 5,139
Patient days	[2] 30,558	[4] 35,973
Average length of stay (days)	[5] 7.6	[3] 7.0
Patient days per person per year [6]	0.94	0.78
65 years and over		
Service population [1]	2,714	4,056
Admissions	[2] 1,520	[3] 2,499
Patient days	[2] 21,728	[4] 26,239
Average length of stay (days)	[5] 14.3	[3] 10.5
Patient days per person per year [6]	8.01	6.47
Total, 15 years and over		
Service population [1]	35,243	50,136
Admissions	[2] 5,551	[7] 7,638
Patient days	[2] 52,286	[7] 62,212
Average length of stay (days)	[5] 9.4	[3] 8.1
Patient days per person per year [6]	1.48	1.24
Occupancy rate	[8] 0.90	[3] 0.90
Beds [9]	159	189

[1] From tables 2 and 3.
[2] From hospital records filed with the State.
[3] Policy projection.
[4] (Admissons) (average length of stay).
[5] Patient days ÷ admissions.
[6] Patient days ÷ population.
[7] Sum of numbers for ages 15-64 and 65 and over.
[8] (Patient days) ÷ [(365) (existing number of beds)].
[9] (Patient days) ÷ [(365) (occupancy rate)].

occupancy for Leonard Morse Hospital (the actual rate at the time) and 88 percent for Somerville Hospital.

Finally, the future need for beds at the index hospital is estimated (step 3f) on the basis of the total patient days derived in step 3d (table 4). Somerville Hospital was found to need 104 medical-surgical beds by 1985 and Leonard Morse Hospital, 189.

Surplus Beds in Relevant Hospitals

At this juncture it is essential to ask whether any of the bed need projected for the index hospital should be accommodated by using surplus beds in other facilities available to users of the index hospital. Asking this question challenges traditional hospital practice and assumes the development among hospitals of better referral patterns and greater cooperation than now commonly exists.

Step 4. Other relevant hospitals are identified through the hospital destination data for the cities in the index hospital's primary service area as defined in step 1a (that is, cities that accounted as a group for at least 80 to 90 percent of the admissions to the index hospital). Hospital destination data reflect the choices of patients (strongly influenced by physicians) and suggest which other hospitals are reasonably accessible to how many residents of the primary service area of the index hospital. If some of the city's residents went to hospitals in adjacent cities or towns, then other residents of the area must also be within reasonable access of the same hospitals. Step 4a permits the identification of other hospitals with services realistically available to residents of the index hospital's primary service area. If other factors are anticipated that would alter the status quo, perhaps in- or out-migration of physicians or changes in the service programs of neighboring facilities, the patient origin percentages are adjusted to reflect these changes.

For Leonard Morse Hospital, six general acute-care hospitals were identified as relevant. These, together with Leonard Morse, accounted for more than half of the total hospital admissions originating from each of the nine cities in Leonard Morse Hospital's primary service area (table 5).

In step 4b the number of surplus beds in these neighboring facilities is determined. In each facility the annual mean occupancy rate in the inpatient service at issue is held to a standard. The difference between the number of beds in use on an average day at the current occupancy rate and the number that would be used at the standard occcupancy rate represents the surplus. In our case studies we used the same occupancy standard as that applied in step 3d to the index hospital: 90 percent for Leonard Morse and 88 for Somerville. (Before making the computations, beds which are under construction are added to the existing numbers.) Framingham Union Hospital, for example, had an occupancy rate in its 201-bed medical-surgical service of 81.8 percent in 1973 and an average daily surplus of 17 beds (table 6).

As with other policy figures, the occupancy standard for the other relevant facilities is provided merely for illustration; another figure (or a different means of allowing for fluctuations in hospitals' censuses) can easily be used in the methodology (*7,8*).

Step 5. Determining what portion of the total pool of surplus beds available in the area to assign to the index hospital requires judgment. The methodology calls for assigning a portion between a "minimum share" and the total surplus available.

Table 5. Step 4a: Identification of other hospitals available to residents of primary service area of the medical-surgical service, Leonard Morse Hospital; percentage of patients in each city admitted to specified hospital

	City								
Hospital	*Natick*	*Framingham*	*Wayland*	*Holliston*	*Medfield*	*Millis*	*Wellesley*	*Sherborn*	*Dover*
Leonard Morse	65	9	27	20	26	35	7	43	27
Framingham Union	11	60	15	60	5	16	..	18	..
Newton-Wellesley	5	3	7	2	4	3	50	6	8
Waltham	1	1	14	1					
Emerson			10						
Norwood					13	11			
Glover Memorial					11	4			17
Total	82	73	73	83	59	69	57	67	52

NOTE: Blanks indicate less than 1 percent.

The index hospital's minimum share of the surplus in each of the relevant hospitals can be defined as that portion which represents the percentage overlap between the service areas of the hospitals. This overlap is computed by returning to the hospital-specific patient origin data, looking at the total admissions to each of the relevant hospitals, and calculating the percentage of that total which originates from the cities in the index hospital's primary service area (table 7). Each hospital's mean daily surplus is then multiplied by the percentage overlap of its service area with the primary service area of the index hospital, and the sum of the reduced surplus for each hospital is taken (table 8). (If the surplus should come to 0, it would be set at 1 for use in step 6).

To assign only this minimum share to the index hospital would be conservative; that is, it would imply continued use of hospital resources at present rates. Allocation of the reserve pool of hospital beds entails balancing such factors as physician and patient preference and geography against efficiency and economy. At what point the scales tip depends in part on local conditions. It is unlikely, however, that in any area all the hospitals will at the same time reach peak capacity and exhaust all possibilities for deferring elective admissions and shortening the length of stay.

As a maximum, the index hospital can be assigned the entire reserve pool. For illustration, we assigned Leonard Morse Hospital twice its minimum share, which is 44 beds, about half of the total pool. We

Table 6. Step 4b: Surplus beds in other hospitals identified as relevant to Leonard Morse Hospital

Hospital	*(A) Occupancy rate*	*(B) Number of beds*	*(C) Surplus beds daily* [1]
Framingham Union	0.818	201	17
Newton-Wellesley	0.742	281	45
Waltham	0.871	224	7
Emerson	0.865	111	4
Norwood	0.897	198	0
Glover Memorial	0.709	92	18
Total	....	...	91

[1] Based on a standard occupancy rate of 90 percent: Column C = [(0.9) (column B)] — [(column A) (column B)]

Table 7. Step 5a: Percentage overlap between primary service area of Leonard Morse Hospital and service areas of other relevant hospitals

Primary service area of Leonard Morse Hospital	*Framingham Union Hospital*	*Newton-Wellesley Hospital*	*Waltham Hospital*	*Emerson Hospital*	*Norwood Hospital*	*Glover Memorial Hospital*
Natick	4.84	2.25	0.44	0.28	0.07	0.44
Framingham	38.71	1.91	0.90	0.11	0.48	0.29
Wayland	1.98	1.04	2.10	1.80	0.02	0.11
Holliston	8.60	0.35	0.12	0.01	0.08	0.04
Medfield	0.45	0.41	0.04	0.01	1.29	3.72
Millis	1.00	0.22	0.02	0	0.73	0.95
Wellesley	0.33	14.45	0.19	0.09	0	1.90
Sherborn	0.57	0.22	0.03	0.01	0.02	0.11
Dover	0.03	0.43	0	0.03	0.23	3.21
Total	56.51	21.28	3.84	2.34	2.92	10.77

NOTE: Figures are percentages of hospital's total admissions, all services.

Table 8. Step 5b: Leonard Morse Hospital's minimum share of surplus beds existing in other relevant hospitals

Hospital	*Percent overlap with Leonard Morse Hospital's primary service area* [1]	*Existing surplus* [2]	*Leonard Morse Hospital's minimum share* [3]
Framingham Union	56.51	17	10
Newton-Wellesley	21.28	45	10
Waltham	3.84	7	0
Emerson	0.865	111	4
Norwood	0.897	198	0
Glover Memorial	0.709	92	18
Total	....	91	22

[1] From table 7.
[2] From table 6.
[3] (Percent overlap) (existing surplus).

assigned Somerville Hospital, which is in a highly impacted medical market where travel between institutions is fairly easy, 80 percent of the total surplus, 44 more beds than its minimum share of 61.

Step 6. The current surplus is now projected into the future, using an inverse proportion of the ratio of current demand to future need, from part I. The assumption is that the corrections made for changes in population and utilization for the index hospital provide an acceptable approximation for changes that might be anticipated at neighboring facilities. This assumption must of course be examined in light of the particular case, and necessary adjustments made. For instance, if the index hospital has been operating at an occupancy rate appreciably lower than that of the other relevant hospitals (see step 2), the future surplus will come out artificially low and will need to be adjusted upward. The adjustment is made by using in step 6 a revised current demand figure, calculated from the mean occupancy rate for the other relevant hospitals combined, in place of the existing bed figure and the actual occupancy rate.

For Somerville Hospital, where the projected need is less than the number of existing beds, step 6 increases the available surplus to 141 beds. The surplus available to Leonard Morse Hospital in 1985 is reduced in this step to 37 beds (table 9).

Step 7. The initial estimate of the future need, from part I, minus the surplus available in other hospitals, from part II, gives a corrected estimate of the future need for beds at the index hospital. Comparison of this figure with the existing supply of beds indicates whether more beds are needed, the present supply is adequate, or the number should be reduced. For the Leonard Morse Hospital, the calculation showed a need for 152 beds in 1985, 7 fewer than the existing number (table 9). Should the number of surplus beds available in other hospitals exceed the number of beds needed, as it did for the Somerville Hospital (fig. 2), the index hospital may be totally superfluous.

Although the solution is expressed as a single number of beds needed, it is important to recognize at this juncture that the calculation is not nearly as precise as such a figure might imply. Embedded in this number are uncertainties that are confronted in part III.

Table 9. Steps 5c, 6, and 7: Corrected estimate of future need for beds, medical-surgical service of Leonard Morse Hospital

Item	Number of beds
Index hospital:	
Current demand	159
Initial estimate of future need	189
Surplus in other relevant hospitals:	
Current surplus (table 6)	91
Index hospital's minimum share (table 8)	22
Index hospital's assigned portion [1]	44
Future surplus [2]	77
Index hospital's assigned portion [3]	37
Corrected estimate of future need [4]	152

[1] (Minimum share)(2), where 2 is based on policy judgment.
[2] [(Current demand) (current surplus)] ÷ (future need).
[3] [(Current assigned portion) (future surplus)] ÷ (current surplus).
[4] (Initial estimate) — (assigned portion of future surplus).

Final Determination of Need

Part III of the methodology is directed to all the remaining policy questions. It permits consideration of the economic, political, social, and medical factors related to, for example, the consolidation or regionalization of a particular clinical service within an area, the relationship of health care services to community development, how an area can attract and hold physicians, how to encourage the provision of ambulatory care, or assessment of the quality of care provided by one institution compared with another.

Always underlying these considerations is the proposition that resources for health care are finite, and that providers compete for them. When, for reasons largely unrelated to objective need, one hospital in an area is permitted to add beds, those beds are in theory (and, if the methodology is used consistently over a period of years, in reality) being taken from a neighboring hospital. Forced to react to providers' proposals one at a time, reviewers of certificate of need applications can lose sight of the opportunity costs that invariably result from any decision to invest in one hospital or one mode of rendering care rather than another. For example, in analyzing the cases in retrospect, we found at the end of part II that there was no need for Somerville Hospital, which had been awarded a certificate of need for 134 beds, and that only 152 medical-surgical beds were needed at Leonard Morse Hospital, rather than the 201 beds awarded. Thus, if one accepts the policy assumptions made in parts I and II, the awards implicitly valued the unstated subjective factors at 134 beds, or about $7.4 million annually in operating costs, for Somerville Hospital, and 49 beds, or about $2.9 million a year, for Leonard Morse Hospital (assuming a mean per diem cost of $152 per bed). Decisions such as these have ramifications for other hospitals in the area and more subtle but equally real implications for alternatives to hospital care, perhaps ambulatory care or community-based long-term care, which may be foreclosed when resources are siphoned off by the hospital sector.

Part III also permits assessment of uncertainties in the earlier calculations. The elements of subjectivity, judgment, and ambiguity (for example, in the population projections and in the assumptions that patient origin data are relatively stable or are valid in aggregate for specific services or that changes in the utilization and management of neighboring facilities will parallel those at the index hospital) contribute to the margin for error that must be assumed to exist in the results of parts I and II. An intuitive assessment of the probable magnitude of that error is an important part of the deliberations for part III. The weight given to the various subjective factors make the difference between the corrected estimate of future need found in step 7 and the final determination.

Discussion

The principal advantage of the methodology is its straightforward approach to a bewildering array of interlocking factors. Without changes in the basic framework, the methodology can accommodate various refinements not included in our illustrative cases. It can be adapted to areawide planning, for example, by aggregating the hospitals in an area, estimating the collective need for beds, and apportioning the beds among the several facilities. For a planning agency or State regulatory agency frequently involved in assessing the need for hospital beds, the methodology could be programed for computer processing, thus streamlining the analysis considerably.

Although the case studies relate to urban and suburban hospitals, the methodology can be used as well for rural hospitals. The norms and assumptions would be tailored to rural needs. For example, the standards for occupancy rate and average length of stay would probably be relaxed to compensate for geographic dispersion of the population and to assure adequate access.

Both case studies are concerned with the medical-surgical service, but the methodology has been used also to forecast the need for beds in pediatric and obstetrical services. However, service-specific patient origin and destination data become increasingly important with services that account for small proportions of the hospital's annual admissions. Patient origin patterns of the entire hospital are influenced strongly by and are a reasonable proxy for those of the medical-surgical service, but this may not be true of obstetrical and pediatric services. For obstetrical services, annual analyses of live birth certificate data might substitute for costly patient origin studies (*9*).

For the case studies, we used 1970 decennial population data and 1973 hospital statistics: the "current" category therefore ranged over 3 years. Population data for 1973 would have been preferable, but the methodology was designed to be as fair as possible without optimal data, which are rare in the real world. The information used is laid out systematically so that it can be revised as inaccuracies are uncovered.

Refinements are possible in the calculation of the population served by the hospital. For example, if the current year is thought to be atypical, a 5-year period can be used. If a particular age cohort shows an anomalous pattern of morbidity, mortality, or hospital use, it can be separated out and particular assumptions made about its future patterns. Routinely, the age group over 65 years is handled separately in the calculation of need for medical-surgical beds, but finer age classifications are equally possible. For example, as the U.S. population ages, it will make sense to monitor closely the health care needs of the population over 75 years old.

If a particular service (perhaps obstetrics) is smaller than an established standard for minimum effective size, it can be removed from the calculation and its admissions assigned to a neighboring facility. If there are other problems with the patient origin data, the respective "market shares" of the individual hospitals can be adjusted before projecting them into the future.

With respect to the surplus beds in neighboring facilities, part III calls for consideration of accessibility and travel time and of whether one hospital's services can be substituted for another's. The questions raised are not easily quantified. How should "reasonable access" be defined? Do the nearby hospitals have sufficiently similar characteristics—similar case mixes perhaps—to make them a genuine comparison set? How entrenched are patterns of physician referral and traditions governing staff privileges? How many idle beds are truly surplus? How much cushion is there in elective admissions? How much hospitalization outside the area is appropriate? How much is purely for convenience or preference? As a rule, should traveling to a hospital remote from one's place of residence be encouraged?

As experience with policy determination in these areas accumulates, some quantitative answers may emerge; these can be incorporated directly into part

II of the methodology. Meanwhile, the working assumption is that the surplus beds of a hospital whose service area overlaps that of the index hospital offer a potential reserve at least in direct proportion to the overlap.

The occupancy rate factors for both the index hospital (step 2) and the other relevant hospitals (step 4) can be replaced by a more complex consideration of peaking and queueing to estimate the need for buffer capacity. However, a simple sensitivity analysis convinced us that corrections for midweek and midyear peaking are not important to the forecast.

Because data are insufficient, part III does not now call for consideration of the relative costs of services among individual hospitals or between hospitals and possible alternatives to hospital care. Information on the costs of care in a format conducive to comparisons across institutions and across modalities of care is badly needed for health planning. When it becomes available, such information ought routinely to be included in all forecasts of the need for services. In this methodology it would be considered in part III.

We deliberately excluded certain other considerations from the methodology. For example, we rejected as impractical the inductive method of building from morbidity data to a finding of need for beds and used instead age-specific admissions as a proxy for hospital disability days. Theoretically, these days can be predicted from detailed morbidity statistics, but, realistically, the data are not available in sufficient aggregation to be useful except for special problems such as end-stage renal disease.

On the assumption that there is a common human need relatively unrelated to socioeconomic status for a minimum amount of inpatient care, and that the improvement of the health of the poor seldom depends on building more hospital beds, income variables are also excluded from the calculations.

The methodology is a planning tool, but it is not a shortcut to difficult decisions; in fact, it could increase the discomfort of making them by exposing their frequently weak foundations. Although it leaves unanswered the major policy questions, we believe it offers a step toward more systematic and less arbitrary decisions by placing the formulation of policy into operational context. Policy is meaningless unless it is both a product and an instrument of decision making. Policy will be capricious so long as the decision making it emanates from is haphazard.

This methodology hinges directly on informed judgment and will not substitute for thinking. But its logical sequence for combining facts and judgments should help pinpoint areas of uncertainty and allow simulation on paper of the effects of alternative visions of the future.

The methodology raises questions of policy and sets them in bold relief. Subjectivity, judgment, and uncertainty will continue to pervade health planning and regulation. Legitimate questions remain about our fundamental premise that restricting the supply of hospital resources will move the delivery system toward greater efficiency and equity. Certainly, restricting supply is futile unless certificate of need decisions are coordinated with licensure, utilization review, and financing programs.

Working in an uncertain milieu, health planners must delineate as clearly as possible where objective analysis of fact leaves off and subjective weighing of imponderables begins. Use of a method such as the one set forth in this paper will not reduce the conflict in allocating hospital beds and indeed it may intensify conflict. But use of such a method will also tend to foster the fair resolution of these conflicts and to increase the public accountability of the decision-making process. In clarifying the policy implications of decisions regarding the allocation of resources, use of the methodology can help to rechannel the debate into conscious and constructive focus on policy issues of consequence.

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