ESTIMATING BED REQUIREMENTS
FOR
NURSING CARE FACILITIES
A Revised Method

A thesis submitted in partial satisfaction of the requirements for the degree of Master of Science in
Health Services Administration
by
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ABSTRACT

ESTIMATING BED REQUIREMENTS
FOR
NURSING CARE FACILITIES
A Revised Method
by
Barry Vernon Nelson

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The objective of this thesis is to perform a critical analysis of the existing methodology used in projecting future bed requirements for nursing care facilities and develop a revised formula that more accurately reflects the parameters determining the number of beds required. The present formula does not take into account queues or shifting ratios of groups within a population and uses a fixed occupancy rate.

By defining patient queue day as any position in the queue which is occupied by a patient for a day, the total bed days needed becomes the number of patient bed
days plus the number of patient queue days. By dividing the total population into groups, the revised formula can better reflect different population growth rates of the groups. The revised formula incorporates average waiting time in a queue rather than using a fixed occupancy rate.

The revised formula is based on the same fundamental idea as the present formula: that of applying rates determined by statistics in a base year to a projected population at some point in the future. The revised formula does, however, more closely reflect the character or mix of the base population as well as any projected changes in that mix. In addition, it introduces a means of including queues in determining the total actual demand for beds.
Chapter I
INTRODUCTION

Currently the California State Department of Public Health evaluates proposed nursing care facility construction or expansion in accordance with the Plan for Hospitals.¹ A nursing care facility is a facility for the accommodation of convalescents or other persons who are not acutely ill and not in need of hospital care, but who require skilled nursing care and related medical services.² The Plan for Hospitals, hereinafter referred to as the Plan, defines the method for projecting the number of beds required within each hospital service area. The Plan specifies that the

Nursing care facility bed need estimates for each hospital service area shall be determined on the following basis:
Beds needed at 90 percent occupancy to serve the estimated population for 1977 times the number of patient days per 1,000 population reported for 1970.³

The procedure for determining the number of beds required can be restated in the form of a formula as follows:

² Ibid., p. 4.
³ Ibid., p. 63.
Let

\[ P_1 = \text{population of the hospital service area in the base year (1970)} \]

\[ P_2 = \text{population of the hospital service area in the projected year (1977)} \]

\[ B = \text{number of nursing care patient bed days experienced during the base year} \]

\[ Y = \text{number of nursing care beds required for projected year.} \]

Then

\[ 0.90Y = \frac{B\left(P_2/P_1\right)}{365} \text{ or } Y = \frac{B\left(P_2/P_1\right)}{0.90(365)} \ldots \text{equation (1)} \]

The above formula assumes the number of patient bed days per 1,000 population in the projected year will be equivalent to that experienced in the base year.

The objective of this thesis is to perform a critical analysis of the existing methodology used in projecting future bed requirements for nursing care facilities as specified in the Plan and develop a revised formula that more accurately reflects the parameters determining the number of beds required.

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4"As determined by the Population Research Section of the State Department of Finance and the Bureau of Census, United States Department of Commerce." Ibid., p. 43.
Although there has been a great deal of effort expended at the committee level in developing the present formula, the Plan gives no reference to any documented analysis or research leading to the current method nor does the Department of Public Health have knowledge of any such papers. The general formula (equation 1) is, however, universally used in all the states and emulates the method set forth in the Code of Federal Regulations. From the preliminary research and discussion with some of those in the field, it appears appropriate and timely to re-evaluate the present formula in light of experience and currently available data.

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7 Roger McDonald, Planning Director, Channel Counties Comprehensive Health Planning Council, Santa Barbara, personal interview, February 21, 1973; also Susan Majarus, Administrator of Villa Maria Convalescent Hospital, Santa Maria, personal interview, May 2, 1973; also Kenneth Wicks, Administrator, Lompoc Hospital District, Lompoc, personal interview, May 3, 1973.
Chapter 2

IMPLICATIONS OF THE PRESENT FORMULA

LIMITED MAXIMUM

From equation (1) it can be seen that, for any specified ratio of \( P_2/P_1 \), the number of beds required would be a maximum if the occupancy rate experienced for the hospital service area during the base year was 1.0. Under such circumstances the maximum number of beds required, \( Y_m \), would be

\[
Y_m = \frac{(P_2/P_1)R}{0.90}
\]

... equation (2)

where \( R \) is the number of nursing care beds in the base year.

If, for example, there was no anticipated population growth (i.e. \( P_2/P_1 = 1.0 \)), then according to equation (2) the maximum number of beds required is \( Y_m = R/0.90 \). This result is significant because it does not specifically account for the length of queues or waiting times and therefore does not represent the total actual demand or total bed need. It simply states that with no population growth, the maximum number of beds required would be 1.11 times the existing number of beds. If the service area had 100 beds in the base year, then regardless of the number of patients that may have been waiting for
a bed, the number of beds allowed would be no greater
than 111.

TOTAL POPULATION DATA

As noted in the introduction, the present formula
(equation 1) is based on the assumption that the number of
patient bed days per 1,000 population in the hospital
service area will remain constant from year to year. The
weakness in that assumption is its use of total population
figures which do not take into account shifting ratios of
age groups within the population. A shift such as this
took place in the southern portion of Santa Barbara
County, California when the group of people over sixty-
five years of age increased from seventeen percent in
1960 to eighteen percent in 1970.¹ The use of this
average utilization rate, the number of patient bed days
per 1,000 population, is only valid when discussing the
base year data. When it is used to represent the
utilization rate of the projected population, however,
it assumes there has been no change in the mix within
that population. This point is significant whenever
there is a disproportionate change of the group with the
highest utilization rate for nursing care facilities and
will be discussed later in the text.

¹Statement by Clifford Pauley, Santa Barbara County
Planning Department, telephone conversation; May 24,
NON-UNIFORM UTILIZATION

Some hospitals as a matter of policy require their associated nursing care facilities to reserve a number of beds to assure their availability to hospital patients no longer requiring acute facilities. By transferring them to nursing care facilities, the associated savings can be then passed on to the hospital patients and the acute beds are available sooner to new incoming acute patients. In order to maintain the necessary availability, the average utilization of the reserved beds will be relatively low. If the reserved beds are included in the normal inventory of the facility, the overall utilization will appear to be low even though there may be patients waiting to get into the unreserved beds of the facility.²

OCCUPANCY RATE

Occupancy rate is defined as the ratio of beds in use to the total number of beds. It is determined by dividing the number of patient bed days (B) by the product of the number of beds (N) and the number of days (D) in the period covered:

\[
\text{Occupancy Rate} = \frac{B}{N(D)}.
\]

Thus the occupancy rate ranges from 0.0 to 1.0 being limited by the number of patient bed days. Being an

average over a period of time, the occupancy rate as defined does not recognize the dynamic nature of the day to day demand for beds. Whereas some days all the beds may be full and patients turned away for lack of a bed, other days many beds go unutilized for lack of patients.

The question arises as to the use of a standard 0.90 occupancy rate in the present formula (equation 1). Seemingly it would allow approximately eleven percent more beds than needed under ideal uniform full utilization conditions and provide a reserve of beds to accommodate additional patients during peak demand periods. The reasoning appears valid enough, but it is doubtful that patient bed days is an adequate estimate of the actual demand for beds. Once again the formula (equation 1) does not take into consideration queues when determining the bed need.

From the above discussion it should be apparent that the present formula (equation 1) does not account for some significant factors which, from a practical point of view, do effect the projected bed requirements for nursing care facilities.
Chapter 3
DEVELOPMENT OF THE REVISED FORMULA

QUEUES

In the formula as set forth in the Plan (equation 1) a patient bed day is defined as meaning any bed which was occupied by a patient for a day. For instance, five patient bed days would be accumulated by either a single patient in the facility for five days or five patients in the facility for one day.

Let it now be assumed that a facility has no beds available at a given point in time and patients are waiting in a queue. Each position in the queue is then analogous to a bed in the facility. A patient queue day can then be defined as any position in the queue which is occupied by a patient for a day. The total bed days needed is therefore the number of patient bed days plus the number of patient queue days. The revised formula begins with

\[ Z = B + Q \quad \text{... equation (3)} \]

where

\[ Z = \text{total bed days needed (total actual demand)}\]
\[ B = \text{number of patient bed days} \]
\[ Q = \text{number of patient queue days} \].
For example, if each patient in a queue was provided a bed for each day he waited in the queue, the patient queue days would be converted to patient bed days. There would be no queue, but the total bed days needed would remain the same.

**POPULATION MIX**

A method of adjusting for age becomes extremely important in case of nursing care facilities where there is usually a higher rate of utilization among those in the sixty-five years and older age group.

To take into account the age factor, let the dividing point be sixty-five (65) years of age as it is common among census data and will serve the purpose here. One group would consist of those under sixty-five years of age. The other group would then consist of those sixty-five years of age and older. As a matter of notation, let "u" designate those under sixty-five and "o" designate those equal to or older than sixty-five years old.

If B is the number of patient bed days experienced during the year, then $B_o$ is the number of patient bed days during the year for patients equal to or greater than sixty-five years of age. Since B now can be thought of as the sum of $B_u$ and $B_o$, the formula (equation 3) becomes

$$Z = B_u + B_o + Q \ldots \text{equation (4)}.$$
Using $Q$ to mean the total number of patient queue days and noting that $Q = Q_u + Q_o$, the formula is further modified to take into account queues as follows:

$$Z = B_u + B_o = Q_u + Q_o \quad \ldots \text{equation (5)}. $$

Regrouping the patient bed days and patient queue days according to age groups

$$Z = (B_u + Q_u) + (B_o + Q_o) \quad \ldots \text{equation (6)}. $$

Using $P_1$ for the total population of the hospital service area in the base year and $P_2$ for the total projected population it follows that

$$P_1 = P_{1u} + P_{1o} \quad \text{and} \quad P_2 = P_{2u} + P_{2o}. $$

$R_u$ can now be defined as the ratio of the total bed day need for people under the age of sixty-five ($B_u + Q_u$) to the total number of people less than sixty-five years old in the hospital service area during the base year ($P_{1u}$).

$$R_u = \frac{B_u + Q_u}{P_{1u}} \quad \ldots \text{equation (7)}.$$ 

and similarly

$$R_o = \frac{B_o + Q_o}{P_{1o}} \quad \ldots \text{equation (8)}.$$

Noting that the utilization with each group will remain relatively constant, it follows that these ratios ($R_u$ and $R_o$) will remain relatively constant. By applying them to the projected population ($P_2$), the estimated total bed days needed for the projected population ($Z_2$), then becomes

$$Z_2 = R_u P_{2u} + R_o P_{2o} \quad \ldots \text{equation (9)}.$$
In terms of the original statistics, the formula becomes

\[ Z_2 = \frac{(B_u + Q_u)}{P_{1u}} \cdot P_2 + \frac{(B_0 + Q_0)}{P_{1o}} \cdot P_{2o} \]

or

\[ Z_2 = \frac{(B_u + Q_u)}{P_{1u}} \cdot P_{2u} + \frac{(B_0 + Q_0)}{P_{1o}} \cdot P_{2o} \] ... equation (10)

For example, assume the following:

\[ P_{1u} = 1,000 \]
\[ P_{1o} = 1,000 \]
\[ B_u + Q_u = 100 \]
\[ B_0 + Q_0 = 500 \]
\[ P_{2u} = 1,000 \]
\[ P_{2o} = 2,000. \]

The total bed days needed using the new formula (equation 10) would be

\[ Z_2 = \frac{(B_u + Q_u)}{P_{1u}} \cdot P_{2u} + \frac{(B_0 + Q_0)}{P_{1o}} \cdot P_{2o} \]
\[ Z_2 = (100) \frac{1000}{1000} = (500) \frac{2000}{1000} = 1100 \text{ bed days}. \]

If, however, total population figures were used, the total bed days needed would simply be

\[ (B = Q) \frac{P_2}{P_1} = (600) \frac{3000}{2000} = 900 \text{ bed days}. \]

By treating each of the two age groups separately, it can be seen that the formula (equation 10) will better take into account different population growth rates of the groups.

**BED CLASSIFICATION**

The problem of non-uniform utilization is the
proper identification of the use of each bed in a facility. Only those beds actually available as nursing care beds should then be included in the inventory for that category. Beds within a nursing care facility which are reserved for some other use should be included in the inventory category covering that other use.

For example, consider a twenty (20) bed nursing care facility being affiliated with a one-hundred (100) bed general hospital which requires the nursing care facility to reserve ten (10) beds for convalescing acute patients. Further, let the occupancy rate for the reserved beds be fifty percent (0.50) and the unreserved beds be one hundred percent (1.0). Using the present inventory procedure of including all the beds in the same category, the occupancy rate for the facility would be

\[
\frac{10(0.50) + 10(1.0)}{20} = 0.75 \text{ or seventy-five percent.}
\]

In reality, however, there are no beds available for other than acute patients from the hospital. By including only those available in the inventory of that facility, the occupancy rate of one hundred percent (1.0) would more accurately represent the utilization of the unreserved beds which are the only ones actually available.

**TIMES IN QUEUES**

Finally, as was suggested earlier, the occupancy rate of ninety percent (0.90) used in the present formula (equation 1) does not reflect the existence of queues. In
fact, the criteria should be the length of time a patient has to wait for a bed. To arrive at this estimate for the projected population let

\[ S = \text{average length of stay in days (excluding time in a queue)} \]

and

\[ Y = \text{number of beds required for the projected population.} \]

Assuming \( S \) to remain constant and under the conditions of full utilization (occupancy rate = 1.0) with no queue, the average number of beds available each day (A) would be

\[ A = \frac{Y}{S} \quad \text{... equation (11).} \]

Using \( Z_2 \) as defined earlier, it can be seen that the estimated average number of new applications for admission per day (W) would be

\[ W = \frac{\text{Estimated total bed days needed}}{\text{Average length of stay (365) \times (365)}} = \frac{Z_2}{S \times (365)} \]

... equation (12).

The average waiting time in a queue (T) can now be calculated as \( \frac{W}{A} \). Restating the formula in another form, it becomes

\[ T = \frac{Z_2/S \times (365)}{Y} = \frac{Z_2}{Y \times (365)} \]

or

\[ Y = \frac{Z_2}{T \times (365)} \quad \text{... equation (13).} \]

Although the effect of \( T \) on the revised formula is mathematically the same as the occupancy rate in the
present formula (equation 1), T is not limited to a value of 1.0 and is more efficacious.
Chapter 4
CONCLUSION

The implementation or use of the revised formula, equation (13) would, of course, require additional data to that now available in the Plan. The main data lacking is related to queues. Certainly, records of queues at each facility would need to be maintained. Duplication, i.e., one patient listed in more than one queue at a time, could be avoided by allowing the patient queue days at a given facility to be based on the proportion of the number of patients admitted from a queue to the total number of patients in queues.

For example assume a total of one hundred (100) patients had waited in queues at a given facility for a total of three hundred (300) patient queue days, but only fifty (50) of them had been admitted. The patient queue days for that facility would then be

\[
\left( \frac{\text{patients admitted from queue}}{\text{total number of patients in queue}} \right) \times \text{total patient queue days}
\]

or

\[
\left( \frac{50}{100} \right) \times 300 = 150 \text{ patient queue days allowed.}
\]

It can be seen that the other fifty patients, having left the queue, would be taken into account at the facility where they were ultimately admitted. It would also allow for different patient selection techniques.
at the various facilities within a hospital service area. For example, a facility may have a policy of maintaining certain ratios of types of patients and select from the queue on that basis rather than "first come, first served."

When applied at the facility level, as opposed to the hospital service area level, the revised formula (equation 13) will reflect the actual bed need at each facility thus providing additional information when deciding priorities of additions or expansions.

Patient origin data would also be helpful and should be used if available in determining the desired location of new facilities as well as expansion of existing facilities, however, it is difficult to incorporate such data into a formula with any meaning. That type of data is more suited to the subjective portion of any analysis and many times involves other intangible factors, such as personal preference or facility reputation.
Chapter 5

SUMMARY

The revised formula developed above is based on the same fundamental idea as the present formula: that of applying rates determined by statistics in a base year to a projected population at some point in the future. The revised formula does, however, more closely reflect the character or mix of the base population as well as any projected changes in that mix.

As noted earlier, the ability to detect and take into account the changes in a population group such as those over sixty-five years of age is very significant in the case of nursing care facilities and perhaps a revised formula of this type (equation 13) should be further evaluated and tested as a method of more accurately projecting the future bed requirements for nursing care facilities.
BIBLIOGRAPHY
