DETERMINATION OF PHYSICIAN MANPOWER REQUIREMENTS USING A SIMULATIVE FORECASTING MODEL

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ABSTRACT

Increased emphasis on solving social problems has demanded better manpower planning in all areas, but particularly in health services planning.

A unique forecasting model is developed for predicting probabilistically the number of physicians required for specified future time periods. Each factor in the model is treated as a random variable with a triangular probability distribution. Exercising the model produces a probability distribution for the incremental number of physicians needed for the specified time period.

The simulation results indicate that community health planners are able to assess future physician requirements probabilistically and with greater confidence than with traditional point estimation techniques.

INTRODUCTION

American management has become concerned in recent years with formal manpower planning and forecasting. Recognition of the crucial role of manpower development in solving a variety of social problems has given new impetus to planning and forecasting for the future. It is now recognized that manpower requirements for all areas of business, government, and not-for-profit institutions must be determined in advance in order to adequately provide for these requirements.

HEALTH SERVICES AND PHYSICIANS

Of particular interest and importance is the planning for manpower associated with health care and services. Even with decreasing birth rates and extended life expectancies resulting from improved medical technology, health planners foresee shortages in many categories employed in the health industry. Predicted shortages of physicians are of primary concern to health planners at the federal, state, and local levels of operation in planning for the future. However, before these predicted manpower shortages may be dealth with, it is necessary to quantify with some degree of confidence the actual incremental numbers of physicians which must be provided at these levels. Of the three levels mentioned, perhaps the greatest emphasis should be placed at the local level, since less forecasting energy, effort, and money seem to have been expended here. Additionally, providing for local community physician needs can be a particularly vexing problem in certain geographical areas. Therefore, any investigation that helps illuminate and attack the local planning and forecasting problem should contribute to its eventual solution.

THE LOCAL UNIT

Although the forecasting model used in this study is applicable to forecasting units of any size or level, emphasis is placed on determining local physician manpower forecasts in order to accomodate local community planning groups. The local unit for which forecasts were to be provided is Lincoln Parish (county) in the state of Louisiana. Lincoln Parish is located in extreme north-central Louisiana and has a population of approximately 33,800. At the time of this study(1973) there were 23 physicians residing and practicing in the parish. These physicians were employed in a variety of health service units, but the majority of them were engaged in patient care through private offices or clinics. A 100-bed hospital is located in Ruston, the parish seat, and a 40-bed addition to this hospital is scheduled for completion within the next year. The problem facing local community and medical officials is to determine how many new physicians will be needed in the parish in the future, and to eventually provide for this number.(1)

THE FORECASTING MODEL

Regardless of the method used, forecasts call for the collection of data which in turn is used to estimate requirements and supplies of physicians for the future. Since estimates typically deal with a future which is uncertain, some judgement and subjectivity is always contained in any forecast. Attempts have been made to improve the forecasting process through the use of statistical and mathematical concepts; however, most forecasts eventually become simply point estimates for some point in future time. In his On Manpower Forecasting, J. E. Morton concludes that

". . .it would seem that the more conventional forecasting methods, sometimes termed naive, should be improved rather than discarded; they are all we really have. Bold attempts, however, should be encouraged. They will, if nothing else, generate new hypotheses that require confrontation and testing."(2)

The approach taken in this study is to effect a marriage of the dichotomy of subjective and scientific methodologies used in forecasting.

PHYSICIAN REQUIREMENTS

In attempting to forecast the incremental number of physicians that will be needed in the future, it is necessary to determine both the expected supply and the expected requirements (demand) for physicians. The incremental number of physicians needed is the difference between supply and demand, assuming that requirements exceed supply. The individual components of physician requirements may be classified according to the employment or occupational groups with which the physicians are associated. Those institutions typically employing physicians include hospitals, nursing homes, practitioners' offices (including those who are self-employed) and other health agencies. The total of all physicians needed to adequately staff these institutions constitutes the total physician requirements at any point in time. By supplying point estimates for each component of physician requirements and them summing these point estimates, a point estimate for the total physicians required can be determined. The algebraic forecasting relationship for these components is shown in the equation,

$$R_e = H_e + N_e + P_e + O_e \qquad (1)$$

in which

R_e = Total estimated physicians required at time t_1
H_e = Estimated physicians employed in hospitals at time t_1
N_e = Estimated physicians employed in nursing homes at time t_1
P_e = Estimated physicians employed in offices at time t_1
O_e = Estimated physicians employed in other health agencies at time t_1.

SUPPLY OF PHYSICIANS

The expected supply of physicians can be determined in a similar fashion. The individual sources providing the supply of physicians may be categorized into three components. These forecast components include the total of existing practitioners at time t_0, the total expected accessions (additions) to the existing supply over the time interval $t_1 - t_0$, and the total expected lossess from the existing supply over the interval of time $t_1 - t_0$. The point in time for which the forecast is being made is defined as t_1 while the present point in time is defined as t_0. The accessions component may be further categorized into new medical school graduates and local forecast unit inmigrants. New medical school graduates are defined as physicians who are accepting their first job in their specialty after completing residency. Inmigrants are defined as those physicians entering the forecast unit from any other source not included in the definition of new graduates.

The loss component may be similarly sub-classified into physician retirements/deaths and physician outmigrants. Outmigrants are defined as those physicians leaving the local forecast unit for employment elsewhere. By supplying point estimates for each of the components and sub-classifications determining the supply of physicians and then summing these point estimates, a point estimate of the total supply of physicians can be determined for the point in time, t_1. The algebraic forecasting relationship for these components is

$$S_e = E + A_{1e} + A_{2e} - L_e - L_{2e} \qquad (2)$$

in which

S_e = Total estimated physicians supplied at time t_1
E = Existing number of physicians at time t_0
A_{1e} = Estimated new medical school graduates during time interval $t_1 - t_0$
A_{2e} = Estimated inmigrants during time interval $t_1 - t_0$
L_{1e} = Estimated retirements/deaths during time interval $t_1 - t_0$
L_{2e} = Estimated outmigrants during time interval $t_1 - t_0$.

If $R_e > S_e$ at time t_1 and estimated requirements must be met, then some increment must be added to the supply of physicians. Therefore,

$$R_e = S_e + \Delta S_e, \text{ and} \qquad (3)$$

$$\Delta S_e = R_e - S_e \qquad (4)$$

in which

ΔS_e = Estimates incremental number of physicians which must be supplied during the interval of time $t_1 - t_0$. This number represents a number over and above the naturally generated supply expected.

Regardless of the level at which the forecasting model is applied, it is this increment to the physician supply that concerns the planner. For the local forecast unit, community and medical officials must address themselves directly to providing for this increment if the local physician requirements are to be met. The complete algebraic forecasting model is shown in Figure 1.

SIMULATION OF THE MODEL

Exercising the model shown in Figure 1 for some point in future time, t_1, will produce a point estimate for the additional incremental supply, ΔS_e, needed to meet the forecasted requirements, R_e. Although this estimate may be the "best estimate" available, it provides the planner with no insight into the probability of occurrence of particular values of ΔS_e. Some probabilistic insight into the distribution of the ΔS_e values may be determined by treating each forecast component in the model as a random variable and generating a probability distribution for each unknown component. By simulating the forecasting process a large number of times, a probability distribution for the random variable, ΔS_e, can be generated. This probability distribution offers the advantage of a complete statistical analysis of the random variable, enabling the planner or decision maker to compute various measures of

FIGURE 1

Physician Forecasting Model

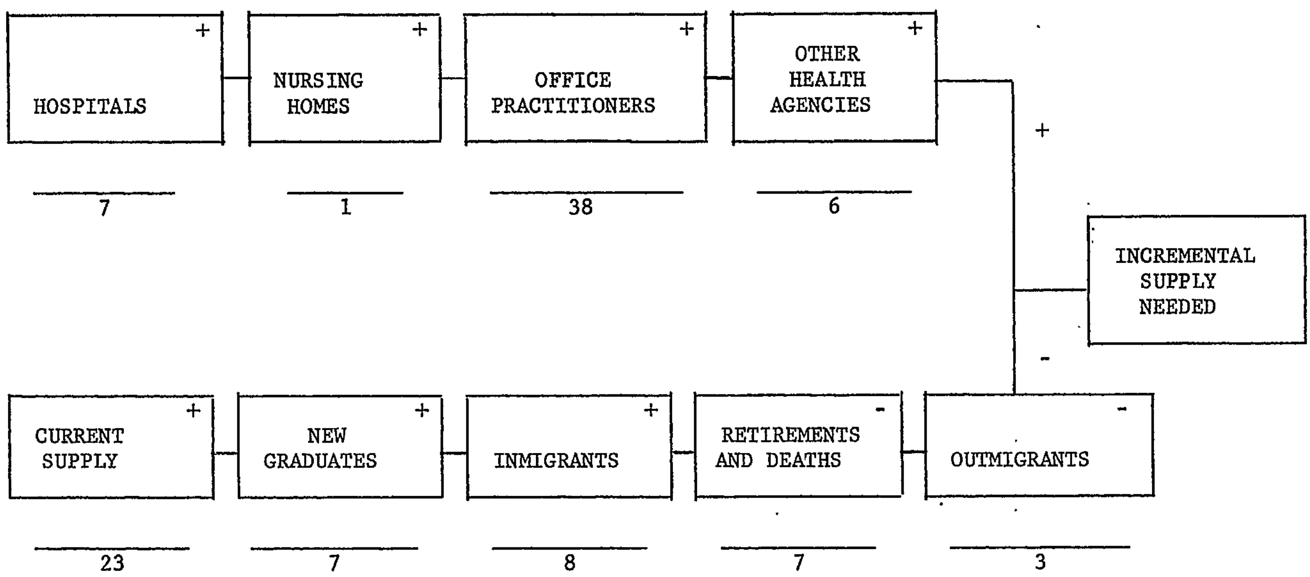
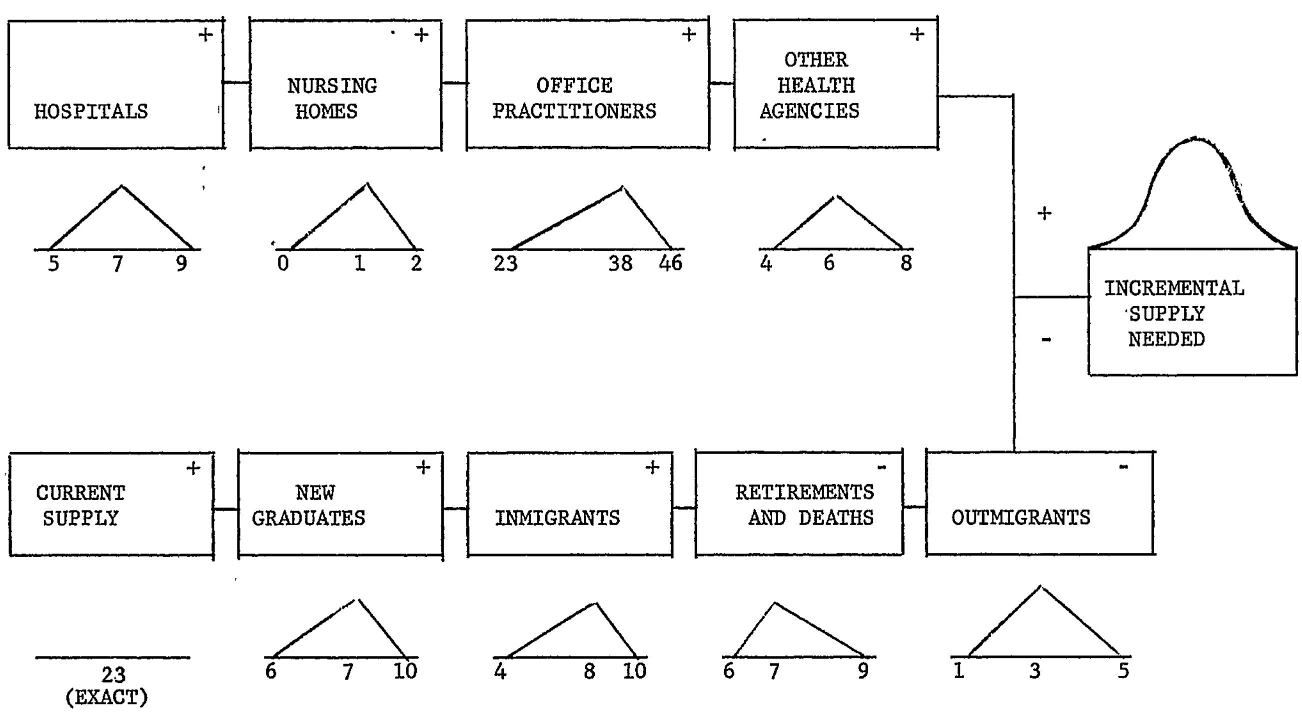


FIGURE 2

Simulative Physician Forecasting Model



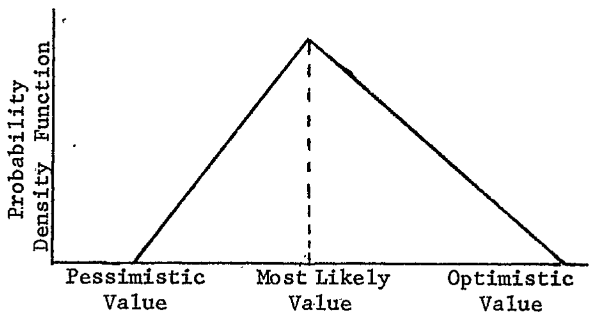
central tendency and variability. Perhaps of even greater importance is the ability to make probability statements regarding the values which the random variable may assume. If each unknown component in the forecasting model in Figure 1 is treated as a random variable, then the simulation of the forecasting model can be pictorially illustrated with probability distributions as shown in Figure 2.

COMPONENT PROBABILITY DISTRIBUTIONS

It is doubtful that the distributional nature of the forecast components in the model will ever be known with certainty. However, the approximate determination of these probability distributions can be handled in several ways, one of which is to develop three estimates: an estimate of the most likely value, an estimate of the most optimistic value, and an estimate of the most pessimistic value. These three estimates can then be used to postulate and construct a triangular distribution(3), as suggested in Figure 3. The triangular distribution was selected for its ease of manipulation and because the estimates required to develop the distribution can be very accurate when determined with the help of experienced community and medical officials.

FIGURE 3

Conceptual Triangular Distribution



The estimates provided by local officials were made for the year t_1 = 1983, and were influenced by population growth rates extracted from census data, by existing and desired physician/population ratios, by existing or planned expansion of hospitals, nursing homes, and other health agencies and institutions, by the distributions of ages of physicians in the local forecasting unit, by existing and planned expansion of medical education facilities in the state, etc. The optimistic, pessimistic, and most likely values for each random variable in the model are shown in Table 1. Once these estimates are provided, a computer program can be used to generate each random variable's triangular distribution. Once these distributions are generated, the simulation process can proceed.

SIMULATION RESULTS

One thousand replications of the model are shown in Figure 2 for the year 1983. As a by-product, the model provides intermediate probability distributions for the supply of physicians and for physician requirements, in the course of determining the distribution for the incremental number of physicians needed by the year 1983. These three distributions are shown in Figure 4, Figure 5, and Figure 6, respectively. Commonly used statistics computed from these distributions are shown in Table 2, Table 3, and Table 4 respectively, although those statistics associated with the distribution of the incremental number of physicians needed should be of greatest initial interest to community health planners. This distribution indicates that the mean number of additional physicians needed for 1983 is approximately 23, but could be as few as 14 and as many as 28. Probability statements for each distribution are also contained in Table 2, Table 3, and Table 4. These probability statements are based on the assumption that the distributions in question are normally or near normally distributed. A check of the measures of skewness and kurtosis indicates that this assumption is not unreasonable in each case.

TABLE 1

Model Component Estimates

Forecast Model Component	Pessimistic	Most Likely	Optimistic
Hospitals	5	7	9
Nursing Homes	0	1	2
Office Practice	23	38	46
Other Health Agencies	4	6	8
New Graduates	6	7	10
Inmigrants	4	8	10
Retirements & Deaths	6	7	9
Outmigrants	1	3	5

A loose cross check of these simulation results can be made using simple linear projections. These projections produce only point estimates for the various components. Based on linear projections by Burford(4), the population of Lincoln Parish will be approximately 41,958 by 1983. The current physician/population ratio in Lincoln Parish is 1/1470. By comparison, the physician/population ratios for the state of Louisiana and for the United States are 1/958 and 1/808 respectively, based on 1970 census figures. Using the linear projections for population and the local, state, and federal physician/population ratios, Table 5 was constructed. Table 5 indicates the number of physicians needed in Lincoln Parish to meet various physician/population ratios, both in 1970 and in 1983. For example, to simply maintain the 1970 physician/population ratio, Lincoln Parish should increase its physicians to a total of 29 by 1983, an incremental increase induced only by an expanding population. If the physician/population ratio is an index of the quality or level of health services available, Lincoln Parish needs an additional six physicians by 1983 just to provide the medical services provided in 1970. Should the parish wish

FIGURE 4

Simulated Distribution for Physician Supply--1983

```
FREQUENCY     0   23   66   99  165  217  187  141   71   22    9    0    0
---------------------------------------------------------------------------
EACH * EQUALS 5 POINTS

       215                             *
       210                             *
       205                             *
       200                             *
       195                             *
       190                             *
       185                             *    *
       180                             *    *
       175                             *    *
       170                             *    *
       165                        *    *    *
       160                        *    *    *
       155                        *    *    *
       150                        *    *    *
       145                        *    *    *
       140                        *    *    *    *
       135                        *    *    *    *
       130                        *    *    *    *
       125                        *    *    *    *
       120                        *    *    *    *
       115                        *    *    *    *
       110                        *    *    *    *
       105                        *    *    *    *
       100                        *    *    *    *
        95                   *    *    *    *    *
        90                   *    *    *    *    *
        85                   *    *    *    *    *
        80                   *    *    *    *    *
        75                   *    *    *    *    *
        70                   *    *    *    *    *    *
        65              *    *    *    *    *    *    *
        60              *    *    *    *    *    *    *
        55              *    *    *    *    *    *    *
        50              *    *    *    *    *    *    *
        45              *    *    *    *    *    *    *
        40              *    *    *    *    *    *    *
        35              *    *    *    *    *    *    *
        30              *    *    *    *    *    *    *
        25              *    *    *    *    *    *    *
        20         *    *    *    *    *    *    *    *    *
        15         *    *    *    *    *    *    *    *    *
        10         *    *    *    *    *    *    *    *    *
         5         *    *    *    *    *    *    *    *    *    *
---------------------------------------------------------------------------

INTERVAL      1    2    3    4    5    6    7    8    9   10   11   12   13
CLASS
```

FIGURE 5

Simulated Distribution for Physician Requirement--1983

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FREQUENCY       0    4   14   39   61  106   95  121  157  144  134   87   31    7
-----------------------------------------------------------------------------------
EACH * EQUALS  4 POINTS

     156                                                *
     152                                                *
     148                                                *
     144                                                *    *
     140                                                *    *
     136                                                *    *
     132                                                *    *    *
     128                                                *    *    *
     124                                                *    *    *
     120                                           *    *    *    *
     116                                           *    *    *    *
     112                                           *    *    *    *
     108                                           *    *    *    *
     104                                 *         *    *    *    *
     100                                 *         *    *    *    *
      96                                 *         *    *    *    *
      92                                 *    *    *    *    *    *
      88                                 *    *    *    *    *    *
      84                                 *    *    *    *    *    *    *
      80                                 *    *    *    *    *    *    *
      76                                 *    *    *    *    *    *    *
      72                                 *    *    *    *    *    *    *
      68                                 *    *    *    *    *    *    *
      64                                 *    *    *    *    *    *    *
      60                            *    *    *    *    *    *    *    *
      56                            *    *    *    *    *    *    *    *
      52                            *    *    *    *    *    *    *    *
      48                            *    *    *    *    *    *    *    *
      44                            *    *    *    *    *    *    *    *
      40                            *    *    *    *    *    *    *    *
      36                       *    *    *    *    *    *    *    *    *
      32                       *    *    *    *    *    *    *    *    *
      28                       *    *    *    *    *    *    *    *    *    *
      24                       *    *    *    *    *    *    *    *    *    *
      20                       *    *    *    *    *    *    *    *    *    *
      16                       *    *    *    *    *    *    *    *    *    *
      12                  *    *    *    *    *    *    *    *    *    *    *
       8                  *    *    *    *    *    *    *    *    *    *    *
       4             *    *    *    *    *    *    *    *    *    *    *    *    *
-----------------------------------------------------------------------------------

INTERVAL        1    2    3    4    5    6    7    8    9   10   11   12   13   14
CLASS
```

FIGURE 6

Simulated Distribution for Physician Increment Needed - - 1983

FREQUENCY	0	4	4	22	27	53	88	70	79	93	107	130	120	107	71	25
EACH * EQUALS 3 POINTS																
129												*				
126												*				
123												*				
120												*	*			
117												*	*			
114												*	*			
111												*	*			
108												*	*			
105											*	*	*	*		
102											*	*	*	*		
99											*	*	*	*		
96											*	*	*	*		
93										*	*	*	*	*		
90										*	*	*	*	*		
87							*			*	*	*	*	*		
84							*			*	*	*	*	*		
81							*			*	*	*	*	*		
78							*		*	*	*	*	*	*		
75							*		*	*	*	*	*	*		
72							*		*	*	*	*	*	*		
69							*	*	*	*	*	*	*	*	*	
66							*	*	*	*	*	*	*	*	*	
63							*	*	*	*	*	*	*	*	*	
60							*	*	*	*	*	*	*	*	*	
57							*	*	*	*	*	*	*	*	*	
54							*	*	*	*	*	*	*	*	*	
51						*	*	*	*	*	*	*	*	*	*	
48						*	*	*	*	*	*	*	*	*	*	
45						*	*	*	*	*	*	*	*	*	*	
42						*	*	*	*	*	*	*	*	*	*	
39						*	*	*	*	*	*	*	*	*	*	
36						*	*	*	*	*	*	*	*	*	*	
33						*	*	*	*	*	*	*	*	*	*	
30						*	*	*	*	*	*	*	*	*	*	
27					*	*	*	*	*	*	*	*	*	*	*	
24					*	*	*	*	*	*	*	*	*	*	*	*
21				*	*	*	*	*	*	*	*	*	*	*	*	*
18				*	*	*	*	*	*	*	*	*	*	*	*	*
15				*	*	*	*	*	*	*	*	*	*	*	*	*
12				*	*	*	*	*	*	*	*	*	*	*	*	*
9				*	*	*	*	*	*	*	*	*	*	*	*	*
6				*	*	*	*	*	*	*	*	*	*	*	*	*
3		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
INTERVAL CLASS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

TABLE 2

Selected Statistics for Physician Supply--1983

SAMPLE SIZE = 1000
SMALLEST VALUE = 23.000 LARGEST VALUE = 32.000
MEAN = 27.662
MEDIAN = 27.68
MODE = 28.
VARIANCE = 3.4638
STANDARD DEVIATION = 1.86
QUARTILE(1) = 26.38 QUARTILE(3) = 28.96
QUARTILE DEVIATION = 1.29
MEAN DEVIATION = 1.49
STANDARD ERROR OF MEAN = 0.59D-01
RELATIVE SKEWNESS = -0.21D-01
RELATIVE KURTOSIS = 2.7
COEFFICIENT OF VARIATION = 6.7

FREQUENCY DISTRIBUTION AND CUMULATIVE FREQUENCIES

CLASS			FREQUENCY	RELATIVE FREQUENCY	LESS THAN ABSOLUTE	LESS THAN RELATIVE	MORE THAN ABSOLUTE	MORE THAN RELATIVE
	UNDER	23.00	0.	0.0	0.	0.0	1000.	1.0000
23.00	UP TO	24.00	23.	0.0230	23.	0.0230	1000.	1.0000
24.00	UP TO	25.00	66.	0.0660	89.	0.0890	977.	0.9770
25.00	UP TO	26.00	99.	0.0990	188.	0.1880	911.	0.9110
26.00	UP TO	27.00	165.	0.1650	353.	0.3530	812.	0.8120
27.00	UP TO	28.00	217.	0.2170	570.	0.5700	647.	0.6470
28.00	UP TO	29.00	187.	0.1870	757.	0.7570	430.	0.4300
29.00	UP TO	30.00	141.	0.1410	898.	0.8980	243.	0.2430
30.00	UP TO	31.00	71.	0.0710	969.	0.9690	102.	0.1020
31.00	UP TO	32.00	22.	0.0220	991.	0.9910	31.	0.0310
32.00	UP TO	33.00	9.	0.0090	1000.	1.0000	9.	0.0090
33.00	UP TO	34.00	0.	0.0	1000.	1.0000	0.	0.0
34.00	AND OVER		0.	0.0	1000.	1.0000	0.	0.0

IF POPULATION IS NORMALLY (OR APPROXIMATELY NORMALLY) DISTRIBUTED

X-BAR PLUS AND MINUS QD	26.369	TO	28.955	CONTAINS 50.00 PERCENT OF THE ITEMS
X-BAR PLUS AND MINUS MD	26.171	TO	29.153	CONTAINS 57.51 PERCENT OF THE ITEMS
X-BAR PLUS AND MINUS S	25.801	TO	29.523	CONTAINS 68.27 PERCENT OF THE ITEMS
X-BAR PLUS AND MINUS 2S	23.940	TO	31.384	CONTAINS 95.45 PERCENT OF THE ITEMS
X-BAR PLUS AND MINUS 3S	22.079	TO	33.245	CONTAINS 99.73 PERCENT OF THE ITEMS

TABLE 3

Selected Statistics for Physician Requirement--1983

SAMPLE SIZE = 1000
SMALLEST VALUE = 37.000 LARGEST VALUE = 60.000
MEAN = 50.304
MEDIAN = 50.76
MODE = 51.
VARIANCE = 24.476
STANDARD DEVIATION = 4.95
QUARTILE(1) = 46.55 QUARTILE(3) = 54.13
QUARTILE DEVIATION = 3.79
MEAN DEVIATION = 4.11
STANDARD ERROR OF MEAN = 0.16
RELATIVE SKEWNESS = -0.27
RELATIVE KURTOSIS = 2.4
COEFFICIENT OF VARIATION = 9.8

FREQUENCY DISTRIBUTION AND CUMULATIVE FREQUENCIES

CLASS			FREQUENCY	RELATIVE FREQUENCY	LESS THAN ABSOLUTE	LESS THAN RELATIVE	MORE THAN ABSOLUTE	MORE THAN RELATIVE
	UNDER	36.00	0.	0.0	0.	0.0	1000.	1.0000
36.00	UP TO	38.00	4.	0.0040	4.	0.0040	1000.	1.0000
38.00	UP TO	40.00	14.	0.0140	18.	0.0180	996.	0.9960
40.00	UP TO	42.00	39.	0.0390	57.	0.0570	982.	0.9820
42.00	UP TO	44.00	61.	0.0610	118.	0.1180	943.	0.9430
44.00	UP TO	46.00	106.	0.1060	224.	0.2240	882.	0.8820
46.00	UP TO	48.00	95.	0.0950	319.	0.3190	776.	0.7760
48.00	UP TO	50.00	121.	0.1210	440.	0.4400	681.	0.6810
50.00	UP TO	52.00	157.	0.1570	597.	0.5970	560.	0.5600
52.00	UP TO	54.00	144.	0.1440	741.	0.7410	403.	0.4030
54.00	UP TO	56.00	134.	0.1340	875.	0.8750	259.	0.2590
56.00	UP TO	58.00	87.	0.0870	962.	0.9620	125.	0.1250
58.00	UP TO	60.00	31.	0.0310	993.	0.9930	38.	0.0380
60.00	UP TO	62.00	7.	0.0070	1000.	1.0000	7.	0.0070
62.00	AND OVER		0.	0.0	1000.	1.0000	0.	0.0

IF POPULATION IS NORMALLY (OR APPROXIMATELY NORMALLY) DISTRIBUTED

X-BAR PLUS AND MINUS QD	46.511	TO	54.097	CONTAINS 50.00 PERCENT OF THE ITEMS
X-BAR PLUS AND MINUS MD	46.196	TO	54.412	CONTAINS 57.51 PERCENT OF THE ITEMS
X-BAR PLUS AND MINUS S	45.357	TO	55.251	CONTAINS 68.27 PERCENT OF THE ITEMS
X-BAR PLUS AND MINUS 2S	40.409	TO	60.199	CONTAINS 95.45 PERCENT OF THE ITEMS
X-BAR PLUS AND MINUS 3S	35.462	TO	65.146	CONTAINS 99.73 PERCENT OF THE ITEMS

TABLE 4

Selected Statistics for Physician Increment Needed--1983

SAMPLE SIZE = 1000
SMALLEST VALUE = 14.000 LARGEST VALUE = 28.000
MEAN = 23.138
MEDIAN = 23.56
MODE = 25.
VARIANCE = 9.6050
STANDARD DEVIATION = 3.10
QUARTILE(1) = 20.74 QUARTILE(3) = 25.61
QUARTILE DEVIATION = 2.43
MEAN DEVIATION = 2.61
STANDARD ERROR OF MEAN = 0.98D-01
RELATIVE SKEWNESS = -0.37
RELATIVE KURTOSIS = 2.3
COEFFICIENT OF VARIATION = 13.

FREQUENCY DISTRIBUTION AND CUMULATIVE FREQUENCIES

CLASS			FREQUENCY	RELATIVE FREQUENCY	LESS THAN ABSOLUTE	LESS THAN RELATIVE	MORE THAN ABSOLUTE	MORE THAN RELATIVE
	UNDER	14.00	0.	0.0	0.	0.0	1000.	1.0000
14.00	UP TO	15.00	4.	0.0040	4.	0.0040	1000.	1.0000
15.00	UP TO	16.00	4.	0.0040	8.	0.0080	996.	0.9960
16.00	UP TO	17.00	22.	0.0220	30.	0.0300	992.	0.9920
17.00	UP TO	18.00	27.	0.0270	57.	0.0570	970.	0.9700
18.00	UP TO	19.00	53.	0.0530	110.	0.1100	943.	0.9430
19.00	UP TO	20.00	88.	0.0880	198.	0.1980	890.	0.8900
20.00	UP TO	21.00	70.	0.0700	268.	0.2680	802.	0.8020
21.00	UP TO	22.00	79.	0.0790	347.	0.3470	732.	0.7320
22.00	UP TO	23.00	93.	0.0930	440.	0.4400	653.	0.6530
23.00	UP TO	24.00	107.	0.1070	547.	0.5470	560.	0.5600
24.00	UP TO	25.00	130.	0.1300	677.	0.6770	453.	0.4530
25.00	UP TO	26.00	120.	0.1200	797.	0.7970	323.	0.3230
26.00	UP TO	27.00	107.	0.1070	904.	0.9040	203.	0.2030
27.00	UP TO	28.00	71.	0.0710	975.	0.9750	96.	0.0960
28.00	UP TO	29.00	25.	0.0250	1000.	1.0000	25.	0.0250
29.00	AND OVER		0.	0.0	1000.	1.0000	0.	0.0

IF POPULATION IS NORMALLY (OR APPROXIMATELY NORMALLY) DISTRIBUTED

X-BAR PLUS AND MINUS QD	20.705	TO	25.571	CONTAINS 50.00 PERCENT OF THE ITEMS
X-BAR PLUS AND MINUS MD	20.533	TO	25.743	CONTAINS 57.51 PERCENT OF THE ITEMS
X-BAR PLUS AND MINUS S	20.039	TO	26.237	CONTAINS 68.27 PERCENT OF THE ITEMS
X-BAR PLUS AND MINUS 2S	16.940	TO	29.336	CONTAINS 95.45 PERCENT OF THE ITEMS
X-BAR PLUS AND MINUS 3S	13.840	TO	32.436	CONTAINS 99.73 PERCENT OF THE ITEMS

to improve the physician/population ratio in 1983 to the 1970 state ratio of 1/958, it would have to provide for an additional 21 physicians (6 + 15) to produce a total of 44. Again, this increment of 21 physicians would only improve the parish physician/population ratio in 1983 to that of the entire state some 13 years earlier. The point estimates contained in the table do not provide the planner with any measure of the confidence of the estimates, although the table figures do compare favorable with the simulation results contained in Table 4 and Figure 6. However, the simulation results enable the planner to probabilistically state the variiability of his estimate over the entire range of values that the random variable, S_e, may assume. This is a decided advantage when planners are called upon to assess a range of forecast values with probabilistic outcomes.

CONCLUSIONS

Although a variety of forecasting techniques is available, most of these techniques simply provide a point estimate for a particular point in time. In attempting to forecast physician manpower requirements for 1983, a simulation model is formulated to describe the forecasting process. Rather than use a simple point estimate for the incremental number of physicians needed in 1983, one thousand replications of the forecasting process were simulated on the computer. These simulations produced a probability distribution for the incremental number of physicians which would be needed in 1983. The mean of this distribution was approximately 23, with the least probable extreme values being 14 and 28. A cross-check using linear projections loosely corroborated the mean value of the distribution but was unable to attach any probabilities of requiring any specific incremental numbers of physicians. Therefore, the ability to forecast via simulations and to produce probability distributions of the forecasted results is seen as a distinct improvement over conventional point estimating procedures in planning for future health manpower needs.

FOOTNOTES

1. The work summarized in this paper was supported in part by a local health planning group.
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4. Burford, R. L., and Murzyn, Sylvia G. "Population Projections by Age, Race, and Sex for Louisiana and Its Parishes," Occasional Paper No. 10, Division of Research, College of Business Administration, LSU, Baton Rouge, June, 1972.

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