Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
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Journal of Applied Sciences 5 (7): 1189-1191, 2005
ISSN 1812-5654

Required Hospital Beds Estimation: A Simulation Study

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Abstract: In this study, we aimed to estimate number of required hospital beds using stochastic process and statistical simulation. Preliminary required data for simulation process is collected from a random sample of hospitalized women in an obstetrics ward. Then, a simulation study was performed in regard to distribution of inpatients. Hospitalization time before and after starting treatment and the number of inpatients in all kinds of services were the principal parameters in simulation process. The initial results from the sample showed that the number of hospitalized women in all services follows a poisson distribution. Additionally, the estimation of required number of hospital beds in this ward was obtained using simulation study. The introduced methods can easily utilize in other obstetrics wards as well as different hospital units. It seems that postulating poisson distribution for inpatients in other hospital units is a valid assumption. May be it's preferable to study this method in other hospital units as well.

Key words: Simulation, stochastic simulation, hospital bed, required hospital beds, poisson process

INTRODUCTION

Optimal allocation of hospital beds in each unit is an important issue in health management. Hospital managers pay a great effort to optimize number of hospital beds to promote patients' care level with decreasing expenses in all communities. As we know, increasing number of hospital beds needs huge budgets and training of health employees. Hence, allocating optimal number of beds to each hospital unit and redistributing of them in different periods of time seems necessary.

Health managers usually evaluate beds occupation ratios in eventual periods of time in order to assess efficacy of allocated resources, but determining all the necessities just by this ratio could not be logical, since this index is just like a snap shot of the present status and could not make the trend of changes clear. Due to high population growth in developing countries, using a few indices like beds occupation ratio and providing the facilities for maximum necessities of health care and programming based on them, could waste valuable and limited resources in these countries.

Based on these facts, proper managing of hospital beds seems to have a great importance in different communities. It's been frequently observed that in some wards, we have vacancies while in others, patients are on long waiting lists for hospitalization, especially in governmental hospitals. For example, it has been claimed that utilization of obstetrics beds is often insufficient because of the randomness inherent in occurrence of births[1].

There are two traditionally common methods for allocating hospital beds. The first method is based on beds ratio per 100000 inhabitants and in the second, that is called target bed occupation, 80 to 85% of allocated beds must be occupied at a period of time. These methods have their own advantages and disadvantages.

To avoid disadvantages of the above mentioned methods, we could utilize more complicated methods such as statistical simulation. Details of theoretical and basic issues for statistical simulation are available elsewhere[2,3]. Another simulation model was developed to determine the number of primary care beds needed in each service area[4].

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Current study has been designed to evaluating the data from a hospital unit and promoting the knowledge and attitude of health managers to improve the health care status in our country. Moreover, a statistical method based on queuing analysis is suggested to estimate bed unavailability in ICUs and Obstetrics units[5].

MATERIALS AND METHODS

This study was performed in the obstetrics ward of Vali-e-Asr Hospital during 2003 in Tehran, Iran. To obtain required information for simulation process, we initially designed a simple questionnaire including; number of daily hospitalized and discharged patients, duration of hospitalization before and after starting the treatment.

This information was gathered from those women who hospitalized in this ward and were treated for delivery (Caesarean Section [CS] or Normal Vaginal Delivery [NVD]), curettage, laparoscopy, Assisted Reproductive Technology (ART) procedures and High Risk Pregnancies (HRP). Then, the distribution of patients for each one of these health services is determined by using Kolmogorov-Smirnov (K-S) statistic in statistical software SPSS. Based on these results, we generate simulated information for status of 10000 days in this ward and finally the probability of occupied beds in each day was calculated. The simulation process is performed by S-PLUS software.

RESULTS

Based on Kolmogorov-Smirnov goodness of fit statistic, our data showed that poisson distribution in all and each type of services is valid for hospitalized patients (Table 1). Table 1 show that poisson distribution is highly acceptable for describing the distribution of data.

Moreover, mean of hospitalization days before and after starting the treatment were determined (Table 2).

By considering the distribution of data and using S-PLUS software, we simulated the information of 10000 days in this ward. Then, based on the mean of hospitalization days before and after treatment (Table 2), we estimated occupied beds per day.

From Table 3, it can be observed that in 41.1% of days, 6-10 beds are occupied in this ward and nearly in 0.5% of days more than 20 beds are needed. It means that we need more than 20 beds just in one or two days per year. In addition, the cumulative percent column in Table 3 shows that we need maximum 15 beds in 90% of days per year (almost 329 days).

Table 1: Estimating the mean of hospitalized patients in obstetrics ward and results of goodness of fit test for poisson distribution

Type of service	Mean of hospitalized patients (Daily)	K-S statistic	p-value
NVD	2.00	0.35	0.99
C/S	1.65	0.29	0.99
Curettage	0.38	0.07	0.99
Laparoscopy	1.20	0.51	0.96
ART	0.46	0.27	0.99
HRP	1.11	0.47	0.98
Total	6.80	0.49	0.97

Table 2: Mean of hospitalization days before and after starting the treatment

Type of service	Hospitalization days (Before)	Hospitalization days (After)
NVD	0	1
C/S	0	2
Curettage	0	2
Laparoscopy	1	1
ART	0	1
HRP	0	2

Table 3: Frequency distribution of occupied beds per day, obtained from simulation data on 10000 days

Occupied beds (per day)	Days	Percent	Cumulative (%)
0-5	325	3.3	3.3
6-10	4111	41.1	44.4
11-15	4542	45.4	89.8
16-20	965	9.7	99.5
21-25	56	0.5	100.0
26-30	1	0.0	100.0
Total	10000	100.0	-

DISCUSSION

Number of required beds to cope with the needy patients is of prime importance for hospital managers. Either underestimation or overestimation of hospital beds will cause serious damages to health system of a community. Hence, the hospital managers and health researchers pay great attention to find optimal approaches for bed allocating.

Several methods and statistical models were already suggested in different articles for approaches of bed allocating were evaluated in France[6]. A simulation study in UK showed that a combination of appropriately analyzing raw data and mathematical modeling provide a good method for estimating number of beds required[7]. Other useful tools for projecting future hospital bed requirements are multistage modeling[8] and artificial neural networks[9].

Interrelation of demand and supply is another interesting theory among health researchers. Many commentators suggested that an increase in the supply of hospital beds tends to generate additional demand either in the form of more patients admitted or patient treated for longer periods of time or some combination of two. In

terms of to five-seventh rule, if a National Health Service bed is made available for an additional week, then for five out of seven days it will be occupied[10].

In our study, the distribution of bed occupancy in all services was poisson. The result of another study demonstrated that emergency bed occupancy on any specific day of the week follows a poisson distribution too[11].

The suggested method in this study can be utilized to estimate required beds in any specific hospital unit. In Vali-e-Asr Obstetrics ward, we have 38 beds. The result of this study showed that 25 active beds can cope with all of the needs. Although in many days of the year we have some vacant beds and hospital must pay the charge of these vacancies. As a final suggestion, manager of a hospital can decide whether to accept these charges or lessen the beds number for optimizing the expenses by considering this fact that he/she would not be able to admit few patients in a few days of the year. For example, in this ward by allocating 20 beds, we can admit all patients in about 364 days (99.5%) of a year.

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