

## Mathematical Modeling in Resource Management : A study on CIMS

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**Abstract:** The hospital administration is a kind of renewable human resource management and so it is one of the core areas of social service and industry. So High Tech Managers are making their strategic planning for the proper functioning of these organizations for its fast growth. In the present paper we study and identify possible solutions for policy makers, in the process of effective human resource generation, especially in the areas of facilities generation. We use mathematical modeling and computer programming for this purpose. In the present paper we study some characteristic values viz. PO, EW and ET as; (i) None of the patients is waiting (PO); (ii) The number of patients waiting for admission (EW); (iii) The average waiting time of a patient before being admitted (ET), by using differential equations with the help of computer programming. These data are collected from the hospital of Chhattishgarh Institute of Medical Sciences, Bilaspur (CIMS) from Dec 2004 to Nov.2005 for twelve months.

### 1. Introduction

The hospital management is also a field of study in the area of renewable human resource generation, comprising the improvements on available number of beds in various wards of the hospital, assignment of duties to the doctors in different wards, preparation and maintenance of office informations, facilities available in the hospital and its planning etc. In the present paper we collect the data on optimum number of beds in some wards, corresponding to the number of patients arriving per day and length of stay by a patient in the ward during the treatment. The management of the number of beds and number of less stay in hospital to provide better service to the patients is the main theme of human resource generation. Some issues of consideration are as follow:

- i) The number of patients arriving per day in the hospital is not linear in nature,
- ii) Period of stay by a patient (number of days) during the treatment in a ward is also not linear in nature,
- iii) Rate of arrival in different wards is also not uniform,
- iv) Weather variations also affect the arrival rate of patients per day,
- v) The nature, extent, & magnitude of disease or casualty on particular span of time and place of occurrence, come into consideration.

D. G. Rao<sup>1</sup>, studied on management break through in hospital management. B. Sharma, L. R. Pratap and A. Kumar<sup>2</sup> studied on application of queuing theory in hospital management using uncontrollable component of demand based on patients' arrival in the hospital without any prior intimation and time spent by a patient in a particular ward during his treatment using queuing theory. Recently S. V. S. Chauhan and S. P. Singh<sup>3</sup> studied mathematical modeling problem on some wards of CIMS, Bilaspur.

The present study is also focused on some wards of CIMS. This study is a kind of renewal human resource for better management.

## 2. Data Collection

Some characteristic coefficients are used for the application of mathematical modeling. The data are collected on following basis;

- (i) The coefficient of probability assumes that none of the patients is waiting (PO),
- (ii) The number of patients waiting for admission (EW),
- (iii) The average waiting time of patient before being admitted (ET),

These characteristic coefficients PO, EW and ET have been evaluated by Computer Programming.

**Table No.1** ; Availability of Beds, Frequency of Arrival and Length of Stay by Patients in Different Wards.

| S.No | Name of Wards   | No.of Beds<br>(s) | Average No.of patients<br>arriving per day (g) | Average length of stay per<br>patient (no. of Days) (u) |
|------|-----------------|-------------------|------------------------------------------------|---------------------------------------------------------|
| 1.   | Male Medicine 1 | 30                | 6.585                                          | 6.5                                                     |
| 2.   | Post Natal Ward | 26                | 5.848                                          | 8.0                                                     |
| 3.   | Paediatrics     | 40                | 5.458                                          | 4.0                                                     |

Table no.1 reflects that average no. of patients (g) arriving per day in various wards is not uniform.

## 3. Mathematical Modeling and Computer Programming

Average no. of patients visiting to ward, is an independent variable which is random in nature. However, average length of stay (service time) can be minimized by providing better service condition and resource generation. The number of beds can also be controlled by the way of good management and thus in this way one can attract more number of patients per day.

Following B. Sharma et al<sup>2</sup>, these are the following differential equations:

$$(3.1) \quad P_n'(t) = -g P_n(t) + P_{n-1}(t),$$

$$(3.2) \quad P_n'(t) = -(g+nu) P_n(t) + g P_{n-1}(t) + (n+1) u P_{n+1}(t), \quad (n < s).$$

$$(3.3) \quad P_n'(t) = -(g+su) P_n(t) + g P_{n-1}(t) + (s) u P_{n+1}(t), \quad (n \geq s),$$

where  $P_n(t)$  is the number of patients at any time  $t$ ;  $g$  is the number of patients arriving per day;  $s$  is the number of beds in a ward and  $u$  is the service rate (i.e. average length of stay per patient in the hospital). The study is based on first come first serve basis following queuing theory, Poisson arrivals of patients and exponential service times. The solutions of the differential equation (3.1), (3.2) and (3.3) have been cited in B. Sharma et al<sup>2</sup> which follow as:

i) The coefficient of the probability that none of the patients waiting for the ward (PO) as:

$$(3.4) \quad PO = \sum_{i=0}^{s-1} \frac{1}{i!} (g/u)^i + (su/(su-g)) (g/u)^s \cdot 1/[s]^{-1}$$

ii.) Average number of the patients waiting for admission in a ward (EW) as:

$$(3.5) \quad EW = (g^3 / ((s-1)u(su-g))) (PO),$$

iii.) The average waiting time of patient before being admitted (ET) as:

$$(3.6) \quad ET = (EW/g)$$

The computer programming regarding calculation of these coefficients (PO, EW, and ET) are done. Corresponding to input values of  $s$ ,  $g$ , and  $u$ ; the output values PO, EW and ET have been calculated by programming.

### Computer Programming

```
#include<stdlib.h>
#include<stdio.h>
#include<conio.h>
main()
{
long int s;
long double fact,fact1,PO,n,g,u,mul,sum,gus;
long double et,sv,gu,su,ew,en,es;
int i,j,e,ctr=0;
char c;
clrscr();
do
{
gotoxy(200,200);
printf(" APPLICATION IN HOSPITL MANAGEMENT");
printf("\n\n enter the value:-----\n \n1]. No.of bed = s \n2]. No. of arriving per day
patients = g \n3]. Average length stay per patient = u\n");
scanf("%ld%Lf%Lf",&s,&g,&u);
```

```

gu=(g/u);
u=((long double)s*u);
sum=0;
mul=1;
fact=1;
for(i=0;i<s;i++)
{    fact=1;
gus=1.0;
ctr=0;
for(j=i;j>0;j--)
{fact=fact*j;}
n=1/fact;
for(e=0;e<i;e++)
{gus=gus*gu;}
mul=(n*gus);
sum=sum+mul;
}
printf("\n summation of A term = %10.10Lf ",sum);
fact1=1;
for(i=s;i>0;i--)
{fact1=fact1*i;}

//    printf("\n s is %10.20Lf=",1/fact1);
fact1=1/fact1;
gus=1;
for(j=1;j<=s;j++)
    {gus=gus*gu;}
mul=(su)/(su-g);
mul=(mul*(gus)*fact1);
printf("\n summation of B term = %10.10Lf",mul);
sum=(sum+mul);
printf("\n summation of both A and B term = %10.10Lf\n ",sum);

```

```

PO=(1/sum);
printf("\n-----");
printf("\n Probability that there is no patient waiting PO = %10.10Lf\n\n",PO);
printf("-----\n\n");
sv=((su-g)*(su-g));
ew=((g*u)*(gu*gu));
sv=((s-1)*sv);
ew=(ew/sv)*PO;
et=(ew/g);

printf(" No. of patient waiting for admission      ==> EW =\n\n",ew);
printf(" Average time the patient must wait before being admitted==>\n\n",et);

fflush(stdin);
printf("\n\n\nARE YOU WANT TO PROCEED (Y/N)");
scanf("%c",&c);
fflush(stdin);
clrscr();
{while(c=='y');getch();}

```

#### 4. Results

The following values of PO, EW and ET have been obtained corresponding to values s, g, and u of Table No.1 using programming.

Table 2 : Various Characteristic Coefficients in Different Wards

| S.No. | Name of Wards   | None of the patients' in waiting. PO | Average no. of patients waiting EW | Average waiting time of a patient ET |
|-------|-----------------|--------------------------------------|------------------------------------|--------------------------------------|
| 1.    | Male Medicine I | 0.3631                               | $0.15 * 10^{-4}$                   | $0.2 * 10^{-5}$                      |
| 2.    | Post Natal Ward | 0.48143                              | $0.12 * 10^{-5}$                   | $0.2 * 10^{-5}$                      |
| 3.    | Paediatric Ward | 0.2556                               | $0.11 * 10^{-4}$                   | $0.2 * 10^{-5}$                      |

In the above table, the values of EW and ET are very small, hence the values of PO for different wards will be considered significantly in the renewal of resource. Keeping the values of PO in view so that it may be uniform in each ward, the service capacity of

different wards has sufficient scope of accommodation for arrival of more patients, with less number of days staying in hospital, even if, they come randomly.

So we suggest the following improvements in the following wards of CIMS for better human resource management regarding the number of beds (s); average number of patients per day coming to hospital (g) and average length of stay per patient (u) so that the coefficient of probability that no patient is waiting in each ward is same.

#### 1. Male Medicine Ward 1

Number of Beds (s)=35; Average Number of Patients per Day (g)=7; Average length of stay per patient (u)=5

#### 2. Post Natal Ward

Number of Beds (s)=35; Average Number of Patients per Day (g)=7; Average length of stay per patient (u)=5

#### 3. Paediatric Ward:

Number of Beds (s)=35; Average Number of Patients per Day (g)=7; Average length of stay per patient (u)=5

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