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Optimization of Hospital Layout through the Application of Heuristic Techniques (Diamond Algorithm) in Shafa Hospital (2009)

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ABSTRACT:

Introduction-The appropriate-use optimization of the limited spaces of the Iranian hospitals is believed to be a crucial step towards promoting the efficiency of these healthcare centers. The issue determining the optimization patterns of the layout of units has led to a lot of efforts by researchers as it increases the efficiency of the hospitals through patients' improvement, changing the location of individuals, patients and facilities. It is right to say that the issue of productivity is neglected in Iranian hospitals concurrently as the question of hospitals layout is not properly addressed.

Method-The present study is an applied research. The method of carrying out this research is based on three basic steps: In the first step, the initial layout of various wards in the subject hospital is determined after the hospital layout was received and numbered for the sake of facility. In the next step an A.R.C (Activity Relation Chart) curve was drawn for all wards of the hospital. Then, the efficiency of the initial settlement was calculated using a diamond algorithm. On the basis of specified relationships and also the hospital current process curve, the new layout plan was presented and the efficiency was recalculated.

Findings-The presented layout has the capability to be utilized in a hospital unit and can encounter various conditions in the present healthcare centers. After the application of the layout improvements the efficiency of the hospital increased up to 45%.

Conclusion-The presented layout pattern in the hospitals to increase efficiency is practically feasible and a real world experience is recommended.

Keywords: *Layout of units, Efficiency, Optimal pattern, Diamond algorithm*

INTRODUCTION

One of the important management issues in designing all production and service systems including hospitals is the location of their internal units (Francis and White, 1974; Papalambros et al., 2000). In order to improve the layout in a hospital as a service system, designers should know the number of facilities that should be settled, the areas occupied by each, the relationship between facilities and some layout limitations of the various equipments (Nicol and Hollier, 1983) as changing the existing layout in any given organization is based on cogent reasons.

✓Minimization of unnecessary coming and going of personnel
✓ Facilitation of relationships and observing individuals' privacy
✓Conformity with organization regulations
✓Securing organization personnel's health and security (Sule, 1991).

As the issue of the layout optimization needs to be addressed in all industrial, agricultural and medical complexes researchers have worked on many concepts in the last four decades. At present, this issue is solved

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in hospitals based on managers' ideas, tastes and experiences. Therefore, there is the risk of encountering consequences such as hidden expenses for the displacement, less use of hospital equipment, false investments and even putting patients' lives in danger (Smith, 2008). In the past two decades, many research activities have been conducted to design healthcare centers, hospitals and clinics optimally (Vissers et al., 2001; Vries et al., 2009). A number of researchers have dealt with the concepts and generalities in planning hospital sources from the point of operation management (Roth and Dierdonck, 1995; Vos et al., 2007). Moreover, some researchers have considered the hospital and its sources as a winding line system**,** and have used the discrete simulation approach to design, allocate sources, layout and its analysis (Van Merode and Groothuis, 2003).

Literature Review

Peponiz and Zimmering have taken the hospital layout design into consideration in their essay (Peponis and Zimring, 1996). There are information vacuums in regard to hospital units as the existing models have inefficiencies due to the special circumstances ruling hospital systems (Feyzollahi et al., 2009). Argot has taken into account the indefiniteness in input data for the design and management issues in hospitals criticizing the definite models of layout (Argote, 1982).

Feyzollahi et al., (2009) have designed a model for the location of hospital service units and assessment of their efficiency on the basis of QAP mathematical model. In this design, the conditions governing the hospital have been considered indefinite and ultimately the efficiency has been improved

Alshafeie (Francis and White, 1974) has designed a model to improve the layout in the hospital based on mathematical principles; the weak point of the presented model is that the conditions governing the hospital have been considered one hundred percent definite while the present project has been designed on the basis of superiority of relationships among clinical and para-clinical wards of the hospital.

Research Questions

The present study answers the following questions.

1. How does the new layout affect the products and services?
2. Are office activities dispersed or concentrated?
3. Does the organization structure support its long term objectives or not?

RESEARCH METHOD

Taking into consideration the high indefiniteness in materials, patients, equipment, personnel etc. in healthcare centers the relationship activities curve has been used to design the layout and location of various hospital services units and their efficiency in the present study. The relationship activities curve is almost the best technique to determine the relationship between activities in various wards (sections). This curve is very efficient in the location for determination of activities in service and treatment institutes. In this curve a number of qualitative signs are used to specify the relationship between activities. The following model designed by Richard Mutter classifies these qualitative signs on the basis of the importance of proximity of activities (table 1).

In planning the facilities, relationship between activities is often interpreted as the need for proximity. For instance, if two activities have a strong positive (+) relationship, they are settled adjacent to one another; and if two activities have a strong negative (XX) relationship, they are settled away from one another. Each activity is shown with the help of its related standard feature mark. First more important relationships are emphasized; that is, it starts from relationship A between wards (sections) and ends in the last relationship; that is, XX.

Important points to be considered in settling awards (sections) are as follows:

✓ Economic and effective utilization of space (particularly height)
✓Flexibility and facility in future expansion
✓Suitable relationship with outer facilities such as possibility of outside transportation
✓Choosing a suitable form for buildings dimension-wise
✓Suitable sequence and network of corridors
✓Observing safety precautions and cases (Nicol and Hollier, 1983).

The type of research is an applied research, and method of data collection is observation and interview with hospital directors. The research has been conducted at *Shafa Yahyaeian Teaching Hospital*, The hospital has 257 beds. This hospital, being a well-known healthcare center in Iran, specializes in rehabilitation

Table 1: Classification of qualitative signs in terms of the importance of proximity of activities

Sign	Feature	Quantity
A	Absolutely necessary *(Proximity of the two activities is absolutely necessary)*	4
E	Special importance *(Proximity of the two activities has a special importance)*	3
I	Important *(Proximity of the two activities is important)*	2
O	Normal *(Proximity of the two activities is good)*	1
U	Unimportant *(Proximity of the two activities is unimportant)*	0
X	Undesirable *(Remoteness of the two activities is better)*	-1
XX	Quite undesirable *(Remoteness of the two activities is necessary)*	-2

and orthopedics. This hospital has wards such as emergency, physiotherapy (hydrotherapy, laser therapy, work therapy, electro-diagnosis, etc) bone density, specialized clinic, and specialized surgery ward. The main building of the hospital is not integrative and on the whole is made of three separate buildings connected to each other through stairs. The layout of the hospitals must be designed by taking many factors into consideration with utmost care as the final product is the patients' health.

In this research, using a survey of hospital architectural plans, first the initial layout in the hospital has been made; then, the hospital status has been analyzed through drawing the current process curve for the hospital and also free questionnaire, and in the next step, the activities relationship curve has been drawn for all hospital wards. With respect to the determined relationships and also the hospital current process curve, the new layout proved to be effective in deceasing the patients' waiting time and increasing the hospital efficiency; as the final step of the study the efficiency in the initial and improved states has been calculated.

Analysis

As the main objective of the present study is to improve the layout of a service-rendering environment the dimensions of wards with no regard to the question of access in a five-floor building have been considered similar for the sake of simplicity of the problem (figure 1).

The cross section of the hospital was drawn to determine the relationship between various wards of the hospital (figure1). As explained in table 1, using qualitative signs, the relationship between wards has been shown from the viewpoint of proximity of activities in figure 2. For example, proximity of CSR ward to the kitchen is quite undesirable, or proximity of emergency ward to ward 1 which is related to the hospitalization of emergency patients is absolutely necessary.

RESULTS AND DISSCUSSION

Applying the curve, one can calculate the initial layout efficiency through using the quantitative amounts presented in table 1 in the following equation: Quantitative amount of activity relationship i with j=P(i,j)

$$\text{Efficiency} = E = \sum_{\substack{1\leq i\leq n \\ 1\leq j\leq n}} P(i,j)$$

Consequently, for the initial establishment, we will have:

E=Σ-2-1+0+0+0+0+1+0+0+4+2+1+0+1+0+1+1+2+3+0+3+0 -1+1+3+2+4+3+2+0+0= 30%

After this stage, the new layout is designed on the basis of the increase in relationship between wards from table 2, and finally the new establishment is offered as in figure 3.

In the end, the efficiency of establishment is calculated after the improvement in layout:
Efficiency of establishment after the improvement=

Σ =4+4+3+4+3+3+4+3+0+4+4+1+4+2+3
3+0+0+0+1+4+3+2+1+1+2+1+1+0+0+0=75%

In this research, it was shown that the designed pattern has the capability of being utilized in the layout of hospital units with a high efficiency by the innovative application an heuristic method initially used in industrial centers. One of the strong points in the

5th floor	Pavion 21	Ward 5 22				
4th floor	Ward 4 19	Operation room 20				
3rd floor	Advanced operation room 17	Ward 3 18				
2nd floor	Radiology 12	Lab 13	ICU 14		Conference hall 15	Physiotherapy 16
1st floor	Emergency 6	Ward 1 7	Management 8	Admission 9	Bone density 10	Specialized clinic 11
Basement	CSR 1	Kitchen 2	Technical orthopedics 3	Records 4	Installations 5	

Figure 1: Initial layout plan

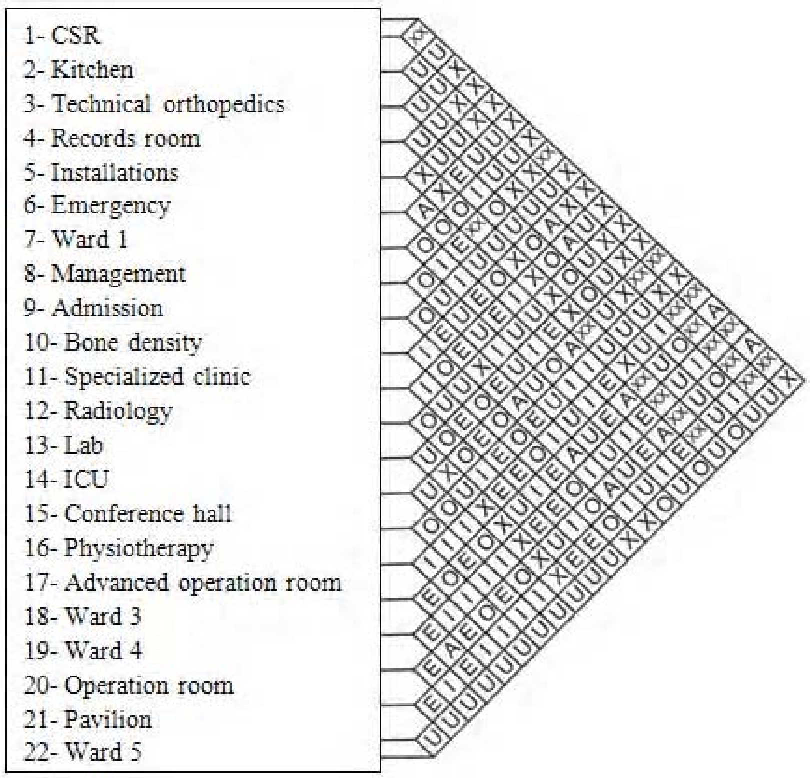

Figure 2: Activities relationship curve for the 22 wards of the hospital

presented design is that in the model attempts have been made to offer guidelines to increase the complexity of the mathematical model to an acceptable extent in addition to supporting the indefiniteness condition so that solving it by heuristic methods using slight changes can be possible.

Table 2: Important relations extracted from activities relationship curve

X's			E's		XX's	A's
13-21	2-16	1-4	11-17	4-7	1-2	1-18
	3-9	1-5	11-19	6-9	1-9	1-20
	3-15	1-6	11-21	6-14	1-15	3-11
	5-6	1-7	12-17	-17	1-17	3-12
	5-7	1-8	12-19	6-19	1-19	6-7
	5-11	1-10	12-21	6-21	1-21	6-15
	5-12	1-11	15-18	7-11	2-15	6-18
	5-13	1-12	15-20	7-12	2-17	6-20
	5-14	1-13	17-18	7-18	2-18	9-1
	5-17	1-14	17-20	7-20	2-19	9-18
	9-13	1-16	18-19	9-11	2-20	9-20
	9-22	1-22	18-21	9-12	2-21	18-20
	10-22	12-5	19-21	9-14	5-9	
	13-15	2-6	19-20	9-16	5-15	
	13-17	2-9		10-18	5-18	
	13-18	2-11		11-14	5-19	
	13-19	2-13		11-15	5-20	
	13-20	2-14		11-16	5-21	

5th floor	Pavion 21	Conference hall 22				
4th floor	Ward 3 18	Bone density 10				
3rd floor	Lab 13	Radiology 12				
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Figure 3: new layout plan

CONCLUSION

The conducted research shows that the efficiency of the hospital with the aim of patients' faster amelioration after the layout has been improved has been increased from 30% to 75%., which is indicative of an increase in the hospital productivity. In the new layout, attempts have been made to bring the wards which have obtained higher points because of proximity closer; whereas in the establishment of wards in Shafa hospital, there are problems such as the proximity of CSR ward to the kitchen or remoteness of the emergency ward from ICU, specialized clinic and the operation room. Hence, in the new layout, innovations to approximate the specialized wards together and to transfer general and non-medical sections such as installations and management, records room and management to one side led to 45% improvement. In brief, the issue of layout in hospital systems is considered as one of the major concerns of managers of those units and experts on medical treatment systems design; and whereas this issue is in relation with the current among various units and life-wise and financially has a high cost, obtaining the best relationship is of utmost importance.

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