ABSTRACT

As cited in literature, the history of hospital design in both practice and theory is rife with proposals -some actually implemented- that lay claim to improving efficiency. The overall aim was to obtain not only lowest possible construction, maintenance and operational costs, but also highest possible patient/user satisfaction, comfort and privacy. Nested within this outlook, the design of hospital nursing units has claimed considerable priority; not only in its own right, but also as a prime determinant of overall architectonic value. Significant in such an endeavor is timely feedback to the designer, especially as quantitative assessments of what has been achieved so far with respect to planimetric efficiency; i.e. utility value of built floor area, both in terms of its allocation to served, serving and circulation spaces and the relative proportions of these. While it was to this broad end that the study being reported on here was undertaken, its particular focus was on the nursing units of public (non-private) facilities located in Turkey.

The study was carried out on a random sample of hospitals operating under government jurisdictions. Sample size was roughly determined as 33%. The material itself consisted of production drawings, as obtained from the archives of said institutions. Plan types of nursing units were examined; nursing units were analyzed with respect to functional classification of spaces constructed; and areas were calculated from these drawings and distributional graphs were constructed.

It was concluded that while the method used was appropriate to the assessment in question, further developments and investigations were needed to develop relevant indicators in order to analyze significant differences among selected hospitals with respect to design efficiency, and to determine the causes underlying any differences if they exist.

Keywords: Hospital Design, Design Efficiency, Nursing Unit Design.
INTRODUCTION

Several different building shapes have been proposed for and applied to healthcare structures in order to increase hospital efficiency. These are, namely, single-loaded corridor, double-loaded corridor, circular form, square form, rectangular form, triangular form, and/or cross-shaped. All these designs attempt to fulfill special aims, which are defined as:

a. obtaining lowest possible construction costs in relation to need;

b. obtaining lowest possible in-use operational and maintenance costs;

c. providing best possible patient care;

d. accommodation/satisfaction of patient privacy and comfort needs.

As cited in literature, the primary determinant of the architectural form and character of hospital buildings is the nursing unit. It is also well known that the efficiency concerns of nursing operations are the dominant factors in the choice of any given plan shape over another. Activities taking place in nursing units, being highly organized into regular routines, are more static than those taking place in any other hospital department; where the diversity, complexity and randomness of activity patterns generated. These practically preclude a concern for efficiency in the same order. This study on planimetric efficiency, therefore, concentrates on the core element of hospitals, the nursing unit.

Several studies have shown that, there are a multitude of factors specific to the inner workings of hospitals, such as walking distances for staff; traffic patterns of users; usable space generated; type, size and diversity of services required, etc., which influence the level of efficiency to be obtained. While nurses may serve more patients in a certain nursing unit with short internal distances than in a unit with long distances.

Considering the dimensions of patient areas, such as patient rooms, their location in nursing units and even the placement of patient beds in rooms are special factors to consider in measuring/achieving design efficiency. They both determine the shape of the inpatient floor and influence the travel distances among rooms.

Apart from circulation and patient areas, serving areas together with their location and organization on the inpatient floor affect the design efficiency. As the number of nurses—or staff—change according to the number of patients, how these changes affect the size and number of wet spaces or nurse rooms or physician rooms is the concern for obtaining adequate efficiency in the unit.

The aim of this study was to analyze nursing units of inpatient departments with respect to their design efficiency, which was assumed to be a significant indicator of not only their constructional and operational costs, but also of their poten-
tial flexibility and adaptability for future changes. It was also thought that this analysis may provide a feedback for researchers, and be of benefit to hospital designers seeking better solutions.

DESIGN EFFICIENCY IN INPATIENT CARE FACILITIES

In this section are described the size and organization of nursing units, plan configurations, and planning for efficient operation in nursing units of hospitals.

The Size and Organization of Nursing Units

Alden (1969) states that although various structural shapes -single corridor, double-corridor, circular or triangular shapes- have been applied to increase hospital efficiency, the size of these units has gained importance. Some advantages of smaller nursing units may be summarized according to Alden (1969) as, the shorter distance between nursing station to the patient beds; the ease of nursing operation; a qualified and personalized nursing unit; the small amount of activities and heavy traffic to avoid confusion.

Alden (1969) also explains that medium-size (40 to 50 beds) units are flexible, and economical for the use of personnel; however, large (50 to 60 beds) units with fewer nursing stations and economical operations are economical to construct.

Aydin (2004), states that the size of nursing units are determined according to how many patients can be cared by the certain number of personnel. For this, the numbers expressed by the Ministry of Health is between 20 and 30, as the author mentions. Spaces excluding the patient bed rooms -such as nursing station, doctors and nurses’ offices, toilets and baths- have standard functions similar among hospitals except some specialistic units such as units for children, women and the units of maternity.

Plan Configurations

Gainsborough and Gainsborough (1964) mention four types of nursing units as;

(1) single-corridor wards with patient rooms are located along one main corridor;
(2) double-corridor wards where the whole area is separated into two spaces as interior and exterior. One of its disadvantages is its higher construction cost; however, its prime advantage is its high operational efficiency. Its advantages are stated as high observability of patient rooms, the flexibility in subdividing wards (in design), shorter distances between destinations, smaller perimeter, and higher amount of heat gain;

(3) square wards which have the largest area compared to its perimeter;
(4) circular wards are also advantageous in terms of the largest area compared to its perimeter and observability from the central nursing area only if the proper diameter size is satisfied (Agron, 1978).
Miller and Swensson (1995) also define triangular shaped units, where the distance between patient rooms and nursing stations is decreased together with construction and maintenance costs. Some generic plans of nursing unit forms are also presented as diagrams in Figure 1.

Some variations in patient accommodation have been observed as multibed versus single-bed room. According to Kliment (2000), eight patients, or six patients or four patients shared rooms; even after the World War II two-patient bedrooms became the norm. Single patient rooms have the advantage for patients’ privacy and comfort, and for hospitals’ aim of maximum available capacity.

Catananti, Damiani, and Capelli (1997) mention also three basic layouts for nursing units; (1) the Nightingale ward with 20 to 30 beds whose heads were placed to the windows; (2) the Rigs ward with beds placed parallel to windows; (3) in the last one these open wards were divided into smaller units with 6 to 10 beds, even 1 to 4 beds. The author goes on further that the best available ward layout can be chosen by four factors, namely, bed need, budget, privacy needs, and intensive care level.

**Planning for Efficient Operation**

Miller and Swensson (1995) state that in circular wards, for nurses patient observation was easy and they could spend more time for each; however, patients complain that they lost their privacy in this efficient unit. Kliment (2000), mentions planning for efficient operation involving various plan types where patients were observed from the central nursing station. Equal chance for each patient, therefore can be given for an efficient care system. Circular units in the 1950’s were the basic models to satisfy this.

Several studies were conducted about this problem, as the author stated (Kliment, 2000). One is the Yale Traffic Index study, which is about traffic patterns in many types of hospitals. They analyzed the frequency of travel in hospitals. The other one is the Medical Planning Associates and Bobrow/Thomas and Associates (MPA/BTA) Nursing Unit Analysis Model, which suggest an indicator of the travel characteristics -the distance-to-bed factor-. The sum of distances from nursing stations to beds which is divided by the number of beds.

Types of buildings are also one of the criteria determining the efficiency of hospitals. Catananti, Damiani, and Capelli (1998), for example, mention that horizontal hospitals with separate buildings are available for hospitals up to 300 beds; since they have low construction and management costs. Monolithic vertical or horizontal buildings are useful for hospitals with more than 300 beds.

Bailey (1956) mention investigations carried out by the Nuffield Foundation and the University of Bristol in order to improve functionality and design of hospitals.
with the use of several mathematical techniques supported with theoretical discussions. The main demand to be considered seemed to organize the size of outpatient department relating number of clinics, the number of patient beds, the size of waiting spaces etc. It is also of great importance to analyze the efficiency of hospitals by constructing research methods in relation to several factors such as walking distances, spaced utilized, light intensity, patterns of movement, services etc.

Traffic Patterns

As is mentioned by Bailey (1956), internal traffic means the movement of human beings and different materials in hospital. In general, spaces with high traffic in intensity should be close to each other while ones with low traffic can be far away; however, such factors as urgency, destination convenience may change configurations. In a route between two spaces there is a constant total traffic flow, which can be minimized by cutting down walking distances for all users of the hospital. In the second problem, they aim to minimize the traffic density in a certain place at a certain time. To measure density seems to be more difficult than to measure total flow. Authors suggest not to design bottlenecks or awkward intersecting lines of traffic; however, to consider the relations of lifts, outpatient clinics and visitors.

Single-Bed Versus Multi-Bed Rooms

As is mentioned by Alden (1969), single patient rooms are preferred and recommended among multi-bed patient rooms; however, it is better to accommodate both single ones and multi ones. Bailey (1956) mentions the ward layout in order to notify the problem of movement within each unit. The compact form is recommended as a good design. The layout and movement inside the unit may be meas-
ured by different factors such as journeys’ frequency of occurrence, types of journeys, and distances etc.

Space Around The Bed

Bailey (1956) states that space required around a patient bed is of primary importance to execute standard nursing procedures without inconvenience. For example, “in bed-making 86 percent of the time was spent within 2 feet [60.96cm] of the bed and 98 percent within 2½ feet [76.20cm]. For beds 3 feet [91.44] in width this gives a minimum distance of 7 feet [213.36cm] between the centers of adjacent beds.” In order to measure this, a method was applied including viewing the number of procedures and record the time; so the distance between the nurse and the bed, and the area used by the nurse around the bed are recorded.

The Net-To-Gross Area Ratios

Hardy and Lammers (1986) define design efficiency as to satisfy the available-high ratio of net usable space to total gross building space. This concept is useful for adjusting construction costs of hospitals by almost 10 percent, in general. This was supported with several studies conducted by The Veterans Administration (VA) and the research staff of the VA Office of Construction. The authors believe that while two hospitals which have similar construction layouts and the same total gross area, will have similar construction costs, the one with a higher net-to-gross ratio will have more usable area with no increase in cost.

Examples of two designs, one with a low net-to-gross ratio and one with a high net-to-gross ratio are shown in Figures 2 and 3 respectively. The former shows a racetrack corridor in a long and narrow planimetric design with a high ratio of perimeter-wall-to-floor area while the latter has a square shape with a low ratio of perimeter-wall-to-floor-area.

MATERIAL

Subject matter (the population) was defined to be health facilities nominally in the public domain. It included both general hospitals and specialistic ones such as pediatric hospitals. However, localized ones according to their administration such as university, military and municipal ones were excluded in order to reach general conclusions.

The material itself consisted of architectural production drawings including dimensions which were used to calculate space areas, constituted a sample space of 44 facilities, from which a roughly 33% random sample of 15 units were drawn. As the investigation proper was specifically delimited to the planimetric design efficiency analysis of nursing units, only typical floor plans pertaining to said units were actually used.
A further aspect regarding the sample space was the diversity in the origins of their designs; while some were of standardized type—as prepared by government bodies according to bed capacity, a considerable number were obtained by commission and a less number by competitions. Such origins have also been noted in the tabulation prepared for data analysis.

**Functional Classification of Spaces**

From the *a priori* assumption that the basic purpose of the nursing floor is the treatment and recuperation of patients, all rooms and spaces thereon were classified into three categories on the basis of whether they were to be considered as *served* spaces, as *serving* spaces, or as those simply providing means of access to and/or among these. This was done in reference to the designations ascribed to individual rooms/spaces on the floor plans, with specific distinctions for classification into the categories just described made according to the author’s interpretation of their functional connotations. To render nomenclature less awkward, categories were renamed according to Düzgünęş (2003), so that those in the first category were designated as *primary spaces*; those in the second, as *secondary spaces*; and those in the third, as *circulation spaces*. The coverage of each is briefly described below.

**Primary spaces:**

In this category were included all patient facilities - bedrooms (both single and ward types), day rooms, perambulation spaces - when specifically designated as such, and isolation rooms. En-suite bathrooms/toilets in patient facilities were also counted in this category.

**Secondary spaces:**

To this category were assigned all other facilities excepting what were counted as circulation spaces, so that it was inclusive of common patient toilets and bath-
rooms, doctor and nurse quarters, examination rooms, clean and soiled linen rooms, mop-up rooms, mechanical and electrical rooms, storerooms for medical supplies and equipment, nurses’ stations, visitor waiting rooms, and any other spaces for support services specific to the type of hospital in the sample.

*Circulation spaces*:

This category included all lobbies and hallways, all stairs and ramps - together with one floor and one intermediate landing, all areas occupied by elevator shafts, as well as all service and main access corridors.

**METHOD**

The actual facilities - quite sizeable in number - seen to fall under the jurisdiction of public administrations were considered both an inapt and a redundant sample space. Instead, resort was made to the archives of the administrations in question; from which it was possible extract a non-repetitive sample space comprised of 44 designs. By virtue of this limitation it was evident that a sample larger than what would ordinarily be the case for such a study had to be used if any meaningful statistical analysis was to be performed on data derived from there; hence the sample size of 15 elements, roughly constituting 33% of the sample space, decided upon. Individual elements were then chosen by simple hat-draw to ensure the necessary randomness. First of all, data sheets were designed to record the various quantitative and descriptive features derived from the material for each sample element. Thus recorded were room/space designations - both as given and as categorized by the author; the various measurements, areas and ratios cited, dates of design commissioning and completion and the type of nursing unit organization.

All nursing unit floor plans thus were grouped with respect to their plan types; namely, single-corridor type, double corridor type -with and/or without courtyard. Two examples of each group were presented in Figures 2 and 3. Ten out of fifteen samples were belonging to the former, while rest of them was belonging to the latter. Several plan shapes also were noted such as rectangular shaped, square-shaped, L-shaped, H-shaped, circular formed floors. Data evaluation was constructed by preparing distribution graphs of primary, secondary and circulation spaces.

The distribution of these areas for each sample displayed in Figure 4 was different for each of them. For sample 15, the minimum percentage as 10.9% of the gross area was the primary spaces, while having the maximum percentage of secondary spaces as the 37.7% of total area. Sample 3 with the rate of 41.3% of primary spaces, sample 15 with the rate 37.7 % of secondary spaces, sample 14 with
the rate of 32.6% of circulation spaces, and sample 11 with the rate of 39.8% of constructional spaces laid in the rank of distribution graphs.

Used for another overview, a number of bar charts were constructed to compare the magnitudes of salient patient-based ratios. Of these, Figure 5 shows a comparison of area of primary spaces per bed with area of primary spaces per bed versus gross area per bed. For sample 15, highest rate was obtained between predefined ratios with respect to lowest ratio of area of primary spaces per bed versus highest value of gross areas per bed. Most of the total gross floor area of that

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Figure 4. Distribution of Primary, Secondary and Circulation Spaces for Each Sample Element, with Deficiencies Indicating Areas Taken up by Constructional Features.

Figure 5. Distribution of Primary, Secondary and Circulation Spaces for Each Sample Element, with Deficiencies Indicating Areas Taken up by constructional Features
nursing unit was occupied with serving areas and other ancillary areas such as cir-
culation and construction spaces; however, lowest rate was achieved for sample
2.

According to the distribution displayed in Figure 6, minimum area of circulation
for one patient bed was obtained in sample 13, also constituting the lowest area
of circulation spaces in total gross area. Sample 15 involves the maximum area
of circulation spaces, with respect to large halls and corridors. Those rates were
also influenced by courtyards, and/or plan types -single- corridor versus double-
corridor types.

RESULTS & DISCUSSION
As cited in literature (Alden, 1969; Kliment, 2000; Miller & Swensson, 1995;
Bailey, 1956; Hardy & Lammers, 1986), there exist several studies carried out on
the design and operational efficiency of hospitals, especially of nursing units;
however, only one study which was conducted by Hardy & Lammers (1986)
dealt with design efficiency of hospitals by using ratios of floor areas as indica-
tors.

Subjects of operational researches stated by Bailey (1956) and Kliment (2000)
were the internal traffic patterns which were analyzed by such indicators, walk-
ing distances and walking routes to improve nursing efficiency in nursing units.
Their aims were significant; that is, obtaining lowest possible in-use operational
and maintenance costs, providing best possible patient care in terms of medical services, obtaining lowest construction costs.

Nursing units examined in this study include three types of planimetric forms, namely, single-corridor type, double-corridor type with/without courtyard as mentioned by Gainsborough & Gainsborough (1964), and Kliment (2000). These satisfy several hospital norms and criteria, such as number of patient beds belong to one nursing unit, adequate space around a patient bed for nursing facilities, designing both single patient bedrooms and/or multi-bedrooms, types of spaces design in a nursing unit floor, locations of nursing stations, etc., mentioned by Miller and Swensson (1995), Alden (1969), Aydin (2004), Gainsborough and Gainsborough (1964), Agron (1978), Kliment (2000), Catananti et al, (1998), Bailey (1956).

Further studies may also be carried out with a larger number of samples including more types of hospitals. Other departments of a hospital or for other building types may be analyzed by using this method.

**CONCLUSION**

This investigation dealt with the design efficiency achieved in the nursing units of purpose-designed public healthcare facilities in Turkey. In this, it concentrated on certain functional areas and ratios deemed to be relevant indications for design efficiency, which may also provide feedback for future designers in this regard.

The areas and distribution graphs considered were derived on the basis of dimensions obtained from the production drawings of sample elements. The drawings themselves were obtained from the archives of the various authorities under which the facilities operated.

Hospitals with various types of nursing unit floor plans; ones with different design origins; and ones located in different provinces were analyzed. Further studies may be constructed in order to analyze significant differences among these by constructing various ratios as analog indicators. These may lead to conclusions on both whether or not there are any development or change in healthcare design criteria for those located in the research area, and whether or not there are any related researches about design efficiency of hospitals. Most preferable, of course, would be that such further researches cover the entire population of healthcare facilities, to include those left out of this study; and that it be well-supported, both financially and academically.
REFERENCES


