AN INVESTIGATION ON THE PLANIMETRIC DESIGN EFFICIENCY OF INPATIENT DEPARTMENTS IN HEALTHCARE FACILITIES

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ABSTRACT

AN INVESTIGATION ON THE PLANIMETRIC DESIGN EFFICIENCY OF INPATIENT DEPARTMENTS IN HEALTHCARE FACILITIES

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As cited in literature, the history of hospital design in both practice and theory is rife with proposals that lay claim to improving efficiency. The aim was to obtain not only lowest possible construction, maintenance and operational costs, but also highest possible patient satisfaction,comfort and privacy. Nested within this outlook, the design of hospital nursing units has claimed considerable priority. Significant in such an endeavour 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. Its particular focus was on the nursing units of public facilities in Türkiye.

The study was carried out on a random sample of hospitals operating under government jurisdictions. Sample size was roughly determined as 33%. The material consisted of production drawings. Data derived from these comprised planimetric measurements regarding their nursing units and of various germane ratios calculated. Analysis of variance, distributional aspects, scatter charts and t-tests were used to evaluate this data according to a number of relevant factors.

Results for ratio of primary spaces to secondary spaces showed that there were significant differences by constructional area per bed, while other variables showed a central tendency that was independent of the factors considered.

It was concluded that while the method used was appropriate to the assessment in question, further developments and investigations were needed to determine the causes underlying such differences.

Keywords : hospital design; design efficiency; nursing unit design; design evaluation.

Öz

SAĞLIK YAPILARINDAKİ YATAN HASTA BÖLÜMLERİNİN PLANİMETRİK TASARIM ETKERLİĞİ ÜZERİNE BİR ARAŞTIRMA

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Literatüre bakıldığında; hastane tasarımının tarihçesi, hastaneleri daha etkerli (verimli) kılma iddiası ile hazırlanmış ve bazıları yaşama geçirilmiş çok sayıda kuramsal ve pratik öneri ile doludur. Bu önerilerin hemen hemen tümünde ortak erek, yapım, bakım ve işletme giderlerini olabildiğince azaltmak, hasta/kullanıcı memnuniyetini, rahatlığını ve mahremiyetini olabildiğince artırmaktır. Bu öngörüye koşut olarak, yatan hasta bakım birimlerinin tasarımı, hem bu birimlerin beklentileri karşılamasında, hem de bütün yapının mimari değer kazanmasında belirleyici olmuştur. Bu uğraşın amacına ulaşması için, tasarımcıya, yapılmış olan hastanelerin planlama etkerliği; yani, işlevsel inşaat alanının hizmet alanlara, hizmet verenlere ve dolaşım mekanlarına nasıl paylaştırıldığı ve bunlar arasındaki oransal ilişkiler hakkında ya da özet olarak belirtilir ise, genel kullanışlılığa ne ölçüde katkı sağladıkları konusunda zamanında bilgi ulaştırmaktır. Bu çalışmada da, Türkiye'de seçilmiş kamu hastanelerinde hasta bakım birimleri belirtilen bu amaç doğrultusunda irdelenmeye çalışılmıştır.

Çalışmada incelenen kamu hastaneleri yaklaşık %33'lük bir rastgele örneklem ile seçilmiştir. Yaklaşık terimi hastane sayısı ancak tamsayı ile belirlenebildiği için kullanılmıştır. İncelemede, ilgili kurum arşivlerinden alınan uygulama projeleri esas alınmış; alan hesaplarına ilişkin veriler doğrudan proje üzerinde yapılan ölçümlerden elde edilmiştir.

Bu ölçümler temel alınarak hesaplanan oranlar, geçerliliği kabul edilmiş etmenlere göre sınıflandırılmış ve saptanan farklılıkların kaynağının saptanması için varyans analizleri, t-testleri yapılmış, dağılım grafikleri hazırlanmıştır. Elde edilen bulgularda, yatak başına düşen yapısal alan sınıflandırılarak yapılan incelemede oranların farklılık gösterdiği, diğer etmenlere göre yapılan analizlerde ise oranların farklılık göstermediği anlaşılmıştır.

Sonuçta, kullanılan yöntemin, belirtilen konularda değerlendirme yapmaya uygun olduğu, ancak saptanan farklılıkların nedenlerini belirlemek için yeni araştırmalar yapılması gerektiği ortaya çıkmıştır.

Anahtar Kelimeler : hastane tasarımı; tasarım etkerliği; hasta bakım birimi; tasarım değerlendirmesi.

To My Parents

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CHAPTER 1

INTRODUCTION

In this chapter are presented the argument and objectives of this study, together with an overview of the general procedure followed. It concludes with a dispositon of subject matter that follows in the remaining chapters.

1.1 Argument

As cited in literature, several different building shapes have been proposed for and applied to healthcare structures—single-loaded corridor, double-loaded corridor, radial access, square form, rectangular form, triangular form, or cross-shaped, *etc,*—in order to increase hospital efficiency. All these designs attempt to fulfil special aims that are of significance to architects, healthcare managers and consultants, as well as to users. These aims are defined as; (a) obtaining the lowest construction costs in relation to need; (b) realization of lowest possible in-use operational and maintenance costs; (c) providing the best possible patient care in terms of medical services; and (d) accomodation/satisfaction of patient privacy and comfort needs.

It is accepted that 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 organised into regular routines, are more static than those taking place in any other hospital department. The primary users, nurses and physicians, by having to carry out specific duties at specific times, necessarily generate practically pre-determined patterns of movement. Nurses, for example, are required make 3 routine visits to patients assigned them by the overseeing physician during a given shift for monitoring bodily functions such as temperature, blood pressure, *etc*. Any non-routine visit is therefore usually in response to a benign patient call or, less often, due to some emergency.

Not so in other hospital departments, where the diversity, complexity and randomness of activity patterns generated by not only the entire body of resident and non-resident users, including patients, visitors and service personnel, but also by the inherrently compound nature of their operations practically precludes a concern for efficiency in the same order. This being the case, it was only a foregone conclusion that, if at all to be made, any analytic investigation into the planimetric design efficiency of hospitals should concentrate on their core element, the nursing unit.

Design efficiency is defined by Hardy and Lammers (1995) as, "achieving a high ratio of net usable space to total gross building space". Studies into the typology of architectural solutions by means of which any given degree of efficiency can be achieved and the developmental processes by means of which these come into being has gained considerable, albeit recent, significance, if not ground, in both architectural and operational research (Bailey,1959:146-157). In view of the results put forth thereby, it seems to be in their own self-interest that architects should constantly strive to find better and better solutions in this regard.

These studies have shown that, along with those concerning the overall scheme, there are a multitude of factors specific to the inner workings of hospitals that influence the level of efficiency to be attained. Among these may be cited walking distances for designated staff; traffic patterns of designated users; usable space generated; type, size and diversity of services required; and so on. These areas, especially in inpatient departments which serve certain users for a certain limited time, directly influence the efficiency of nursing operations in that, for the same period, nurses may serve more patients in a given nursing unit with short internal distances than in a unit with long internal ones. In addition, long distances may result in fatigue for nurses, which negatively influence their performance.

Considering the dimensions of patient areas, including patient bedrooms, wards, *etc*., their location in nursing units and even the placement of patient beds in rooms are special factors to consider in measuring/achieving design efficiency; if nothing else merely on account of the fact that they both determine the shape of the inpatient floor and influence the travel distances among rooms. In a 6-bed patient room, for instance, the situation of six beds in two opposing groups of three versus one where all are in a single row result in not only different corridor lengths but also in different net usable areas. Even in the former, a situation where the room is seperated by a wall in the middle of the space to change the 6-bed patient room to a 3-bed patient room, lead to totally different net usable areas. Dimensions of patient areas and situations mentioned in the example are significant so as to allow ease of movement for nurses and travel around patient beds and rooms. They also influence the dimensions—sizes—of the neighbouring spaces which share the walls, as well.

Apart from patient and circulation areas, other spaces that affect the design efficiency in nursing units are serving areas together with their location and organization on the inpatient floor. If the number of nurses—or staff—per nursing unit changes according to the number of patients in one unit, the rate of change and how these changes affect the size, number and location of nurse rooms, physician rooms or storage rooms will gain importance. In addition, wet spaces may display variation in both number and in size according to the number of patients and/or the number of patient rooms.

Along with factors of design efficiency deriving from the inner workings of nursing units are those that are related to such of their physical attributes as overall size/dimensions and planimetric configuration. Being also known as 'aspect ratio', the role of the latter in determining overall enclosure efficiency (external perimeter length required per unit floor area, where floor-to-floor height is constant) and the repercussions of this with respect to both constructional/operational efficiencies is well-recognized, if not self evident. (For a given overall floor area, the smaller this perimeter length, the less the footprint area occupied by enclosing walls, hence, the more the area left 'free' for use within; and, by the same token, the less the running costs to make up for heating/cooling loads incurred by surface areas thereby exposed to the external environment.) Be this as it may, since the highest theoretical efficiency is given by a circular and the next-highest by a square plan shape—both of which may not always offer the most convenient solution—in practice, this ratio more often than not evolves as a compromise between the concerns just cited and the organizational requirements of the facility in question.

The principal aim of the study was defined under the foregoing considerations as a multi-faceted analysis of nursing units in hospital inpatient departments with respect to their planimetric design efficiency, where this was taken to be a significant indicator of not only their intrinsic constructional and in-use operational costs, but also of their potential flexibility—hence, utility value—insofar as their adaptability to future changes was concerned. It was also thought that the findings of this analysis—confined to a limited sample from a specific category of hospital in Türkiye though it was—would, by providing much-needed feedback, be of benefit to such designers as maybe seeking better solutions in this respect.

1.2 Objectives

The overall objectives of this study were classified into two groups as 'main' and 'secondary', which are defined below.

The main objectives of this study were;

a) to determine net usable areas and gross building areas (inclusive of areas allocated to constructional elements/requirements) in nursing units on inpatient floors;
b) to determine the ratio of net-usable areas to gross building areas in order to construct an indicator for measuring design efficiency in terms of construction, management and maintenance costs; an indicating factor for flexibility and utility demands, as well.
c) to determine the external surface area of nursing unit floors in terms of heat loss, design efficiency and construction costs.
d) to understand whether or not a relationship existed between design efficiency of nursing units and areas of primary spaces per beds by using the ratio of net usable areas to gross areas.
e) to understand if there were significant differences between design efficiency of nursing units and areas of secondary spaces per beds by using the ratio of net usable areas to gross areas.
f) to understand if there were significant differences between design efficiency of nursing units and areas of circulation spaces per beds by using the ratio of net usable areas to gross areas.

g) to understand if there is significant difference between design efficiency of nursing units and external surface area per net-usable areas by using the ratio of net usable areas to gross areas.

The secondary objectives were;

a) to identify patient areas as primary spaces in view of the dimensions of patient areas, their location on the floor, their impact on the dimensions and disposition of corridors in nursing units of inpatient departments,
b) to identify service areas as secondary spaces in view of their impact on both plan shape of the floor and on the operational efficiency of nurses in nursing units of inpatient departments.

1.3 Procedure

The study was carried out in five phases,

In the first, a general survey was conducted to cover the subject domain, including the evaluation of healthcare facilities with regard to particulars of their spatial characteristics, composition, and organisation and related studies concerning the intended area of research were noted.

In the second, a sample of hospital facilities located in various geographical and climatic regions of Türkiye were defined for the quantitative aspects of the study to analyze planimetric design efficiency of their inpatient departments.

In the third, a roughly 33% random sample was constructed to select related hospitals from among a sample space of hospitals belonging to certain institutions in Türkiye.

In the fourth, production drawings of those hospitals falling in the sample were examined; dimensions of spaces on nursing unit floors were noted to calculate areas of spaces and to obtain ratios of net usable floor areas to gross areas as analogue indicators for analysis of design efficiency. In this, the various spaces were classified into 3 main categories as primary, secondary and circulation spaces. (Specific definitions of these are given in Chapter 3.)

In the fifth, analyses of variance (ANOVA) were conducted to determine whether or not there were significant differences among hospitals grouped by areas of primary spaces per beds, areas of secondary spaces per beds, areas of circulation spaces per beds, external surface area per bed, net usable floor area to gross floor area, ratio of external surface area to gross floor area, and constructional area per bed in terms of indicator ratios; t-tests and scatter charts were also constructed to understand whether or not there was direct relationship between primary spaces, secondary spaces and circulation spaces.

1.4 Disposition

The study consists of five chapters, of which this Introduction is the first.

In the second chapter is presented a summary of literature surveyed on general characteristics of hospital planning and design, together with their principal departments, and design efficiency of inpatient care facilities.

In the third chapter is described the study material and the methods used in data collection and its analysis. Relevant elements on design efficiency of nursing units are evaluated through analyses of variance.

In the fourth chapter are given the results of the study, together with a discussion of these in terms of its objectives and the relevant aspects iterated in the literature.

The final chapter, the conclusion, presents the findings of the study, in summary, and offers some recommendations for future researchers.

CHAPTER 2

LITERATURE SURVEY

In this chapter is presented a survey of literature on hospital planning and design issues, which necessarily include an overview of historical background with regard to trends and developments in topology as well as in healthcare practices, insofar as they contribute to the 'complexity' of such topology. This is followed by a general overview of principal hospital departments. It concludes with aspects concerning the design efficiency of inpatient care facilities, including nursing unit evolution and planning configurations.

A total of 48 references are covered in this survey. Owing to the nature of the subject matter and of the investigation itself, these necessarily showed considerable diversity, ranging from items dealing directly with the issue at hand to those on methodology and background. In the interest of maintaining distinction between sources, they have therefore been ordered under three sub-headings in the presentation following, as references on hospital planning and design issues, references on principal departments of hospitals, references on design efficiency in inpatient facilities with 18, 8, 6, and 16 items cited under each, respectively.

2.1 Hospital Planning and Design Issues

Hospitals have been one of the most important institutions among other large complex buildings. They are places where two distinctive events in human life most often take place; namely, birth and death. Equally important, they are where people have to go when they need curative treatment by physicians for their ailments with the help of medical devices and technology, since neither can be handled by themselves.

This section is comprised of two sub-sections; namely, prototypes and trends in design- which covers various types of hospital such as the block type, the pavilion type, the high-rise type, the low-rise type, the village type, and contemporary types, and factors of healthcare design complexity which covers demands of users, developments in science and technology, along with issues of environmental quality, obsolescence, flexibility and expansion.

2.1.1 Prototypes & Trends In Design

Hospitals have developed rapidly and showed remarkable changes of attitude in planning and design issues, mostly in the 19th and 20th Centuries. Kim (2001,85), mentioning basic historical events in describing these changes, states that hospitals are more vulnerable and sensitive to technological, social, and economical changes than any given other building types due to the diversity of their activities during 24 hour day. They house caring units, laboratories, public spaces, surgeries, offices, laundries, mechanical rooms, *etc*. According to the same author, other factors are the interrelationships between changes in healthcare design concepts (from curing to caring) and the components of change.

(a) The Block Type of hospital

This type of hospital was developed mainly in 18th Century. As Kim (2001,92) states, general information from Knowles(1965) that an altar was situated in order to emphasize the patient wards especially in the Medieval and Renaissance periods, owing to the fact that Mass could be visible by all patients in the ward. This religious aspect of hospitals rather quitely diminished medical aspects became more and more dominant in the 18th Century. In short, it was Christianity that lead to the development of early modern hospitals. Miller and Swensson (1995,25-26) agree on this idea that in the early Renaissance period, a modern hospital and an eighteenth-century hospital were similar in functional aspects. The authors describe the prevailing medical theory for that time as being 'miasmatic'. So, people believed that diseases were caused by bad air; so applying natural ventilation to obtain the circulation of fresh air was to be believed as the only preventive solution.

To address principal ideas of eigteenth-century physicians, Kim (2001,92) stated Annabal's (1993) as "the need for cross-ventilation, fresh air, natural light, and adequate orientation of hospital buildings toward the sun and prevailing winds". Hospitals, required to satisfy these demands, due to the fact that people in a poor economical situation were stacked in large open wards, looked like private houses called 'block type'. According to Miller and Swensson (1995,26), these hospitals were to be named 'total institutions', in England, because of building plans reflecting social organizations and differing building structures resembling 'Palladian mansions' whose domestic applications reflect different social activities by different floor heights.

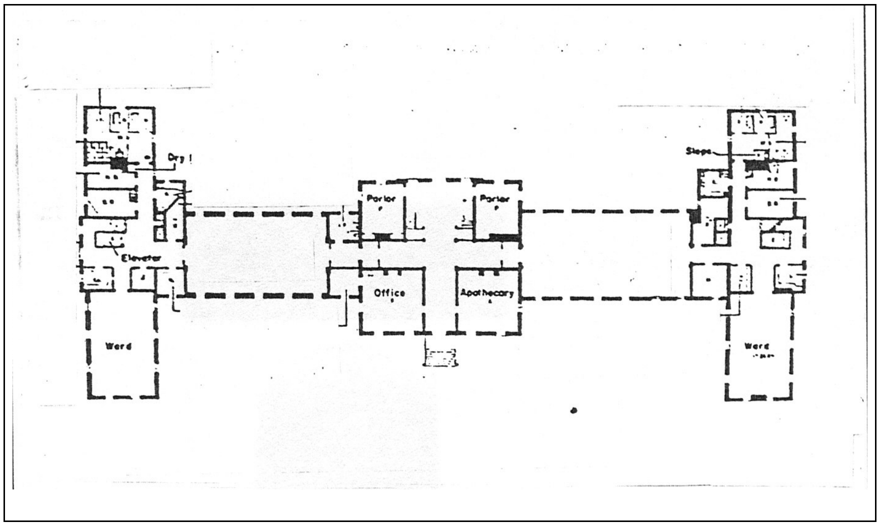

Figure 2.1 The floor plan of Pennysylvania Hospital. (Kliment, 2000, 27).

(b) The Pavilion Type of hospital

According to Kim (2001, 93-94), as a result of miasmatic theory, phsicians believed that “the hospital structure should be divided and detached into units to maximize natural air ventilation in the units, especially in wards”. In addition to this, Florence Nightingale (1820-1910) being a primary nurse in England reached an agreement on this statement by phsicians. Her proposed hospital type was to be formed with ward blocks seperated by an open space e.g. a garden and tied together by a corridor. This predominant type of building in England and the United States was called the ‘pavilion-type’ hospital. Miller and Swensson (1995, 29) summarizes this as a triumph in the mid-nineteenth century. Patients who should not be deprived of fresh air were placed in detached ward units, with a single entrance, consisting of fifteen beds situated along the long side walls.

Kim (2001, 95) states three basic reasons why this type of building was also popular in the medical field, according to Annabal. To begin with, as patients were seperated in detached wards according to their illness type, the contamination risk could be reduced. In relation to this, the working efficiency of medical personnel would increase; since, they applied similar treatments to similar diseases in the same ward units. Finally, “the incidence of hospitalism and mortality rates" was to be minimized because of natural ventilation and appropriate orientation to sunlight and winds. The last assumption, however, could not be approved and no change in the rates of hospitalism and mortality rates were observed. In addition, inefficiency, as a problem, was attained both by staff due to long walking distances between wards and by the building structure due to high construction costs and high energy consumption from large external wall areas.

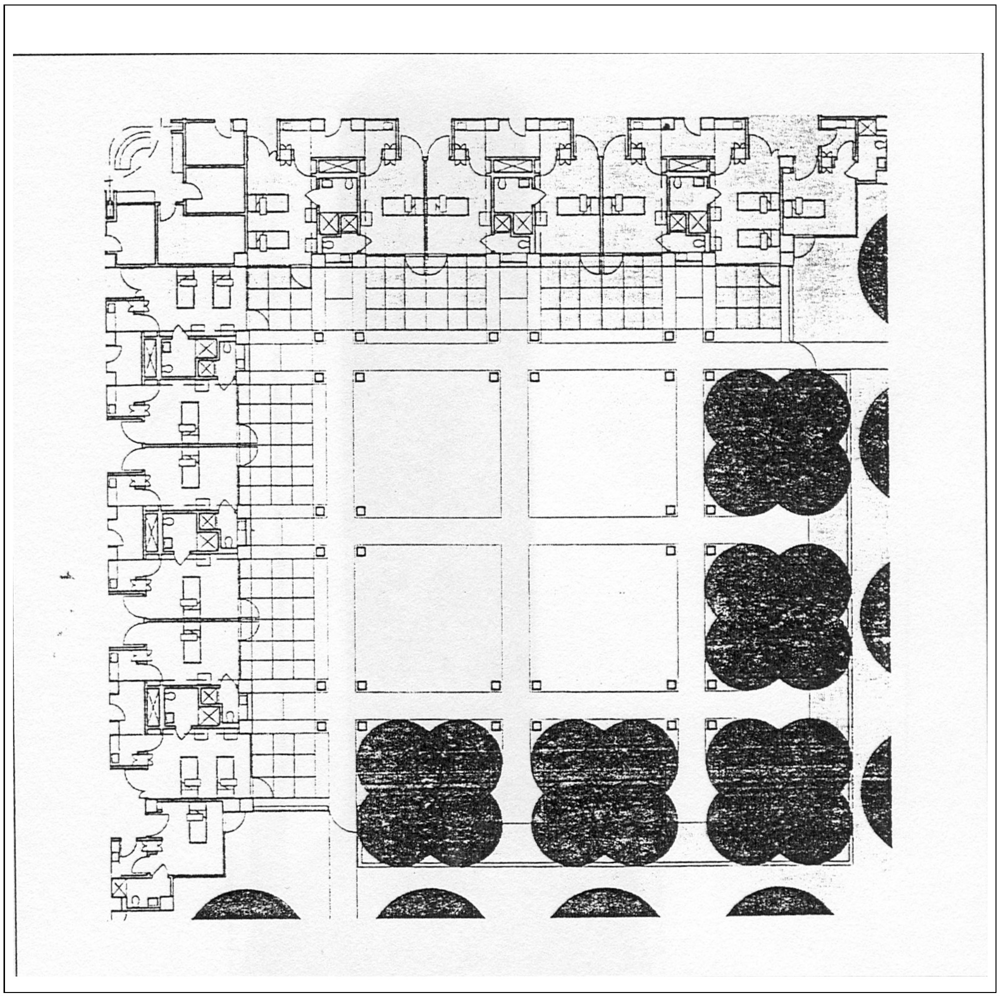

Figure 2.2 Patient pavilion plan and gardens of City of Hope National Medical Center. (Kliment, 2000, 135).

(c) The High-Rise Type of hospital

By the end of nineteenth century, due to some technological improvements such as new mechanical systems, innovation of elevators, and construction techniques, remarkable changes in hospital design were emerged. Not only these technological advancements but also developments in science such as new medical theory—germ theory—argued that diseases were transmitted by micro-organisms, and developments in medical technology such as the discovery of X-rays which allowed the emergence of radiology and radiotherapy, the development of anesthesia contributed to leave the pavilion type of detached ward blocks. Several problems rised such as high construction and maintenance costs of large buildings, and high land values also influenced this happening (Kim 2001, 95-96; Miller and Swensson 1995,29-31; Delrue 1999,100-104, Chand 2002, 64-65). Delrue (1999,100-104) indicates a prime shift in medical service that patients became mobile as a result of new diagnostic and treatment techniques; and bedside care lost its justification for its compulsory use.

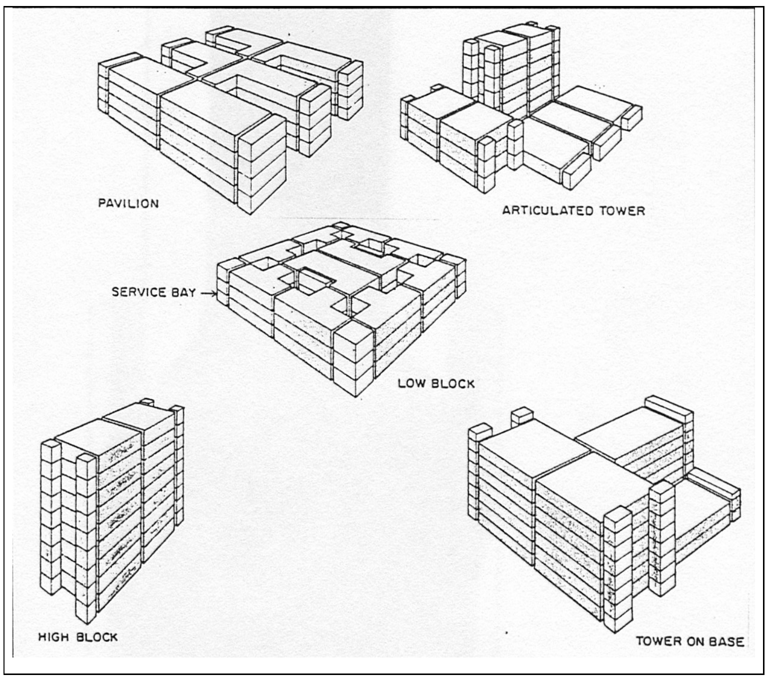

Figure 2.3 Schematic drawings of certain hospital types; namely, pavilion type, high-rise type, low-rise type. (Agron,1978, 23).

As the author goes on, as well as logistics and nursing departments, medical quarters were started to serve patients. For the layout of the facilities, movement patterns and ways of patients gained importance in design.

As it is understood that there could not be obtained any improvement in disease treatments by pavilion type hospitals, they lost their justification for their building shape. Miller and Swensson (1995,30) add that it was, therefore, to be changed together with some internal design decisions such as better lighting and noise conditions, comfortable bed placements, and painting with warm colors unlike white walls of pavilion type hospitals, e.g the Nightingale ward.

Several problems, however, were arised. Kim (2001, 96) has interpreted that all those improvements were not from the patients' point of view, but from the physicians'. The needs of patients were disregarded awhile; these had to compete with the demands of technology, and needs of working staff. With the contribution of technological and medical developments in the field of architecture, the high-rise type of hospitals was constructed under the influence of modern movement. Patients began to complain from these dehumanised and impersonal hospital environments. (Kim 2001, 97; Miller and Swensson 1995, 31). James and Noakers (1994, 11) also points out another disadvantage of high-rise hospitals that they consume high energy; they need high costs for climate control; and they became weak against fire with less fire zones. The rigid vertical building type, which had been extensively used since 1970s in England, is defined, by the authors, as the 'envelope', which does not allow for lateral growth. Although they use lands economically by their rigid floor plans, as is the case for future expansion or change, they may represent unplanned land use with small blocks attached to the main block. This also creates insufficient circulation and operational consequences.

Delrue (1999, 100-104) states that

> In 1912, Dr. Goldwater tried to adapt the Nightingale Ward to the vertical hospital but faced serious problems of flexibility and traffic. In 1942, the symbols of vertical trend, Monoblock structures were emphasized by the idea of double-corridor nursing units but made no contribution to the quality of hospitals. Later on, Europe came up with two alternatives in high-rise hospital design: the tower on a muffin and the tower with a technical block, but both alternatives could not cope with the vertical elevator traffic and this generation came to an end in the 1960's.

(d) The Low-Rise Type of hospital

The low-rise type of hospital is another type that was generated after the period of World War II which was explained again, in the words of Delrue (1999,100-104):-

> Before World War II Goldwater and Rosenfield started to design hospitals in a more horizontal pattern. During and after the war, with the explosion in the medical specialities and departments, vertically organised hospitals suffocated. The "low-rise" hospital period has started with the design of the new medical premises of Stanford University by Isadore Rosenfield and Paulo Aalto in 1957 and there were some contribution to this generation in the 1960's. Another attitude, which is inspired by high-tech building technology, created sophisticated but dangerous healthcare environments. This generation of hospitals, "titanics", were expensive, consume high and costly energy, lacked in flexibility and created sick-building syndrome.

(e) The Village Type of hospital

Another type mentioned in literature is the village type of hospital which was defined according to Delrue (1999,100-104) as:-

> The design philosophy of John Weeks created another generation of hospitals, the Village type designs, which have an open-ended layout for unpredictable growth and continuous change. Leuven, at this time, offered patterns, which allow nearby clustering of highly interdependent hospital departments on one floor. The village-type of hospital is the last generation of hospital and might survive the dynamic evolution in medical and technical, economic and social matters.

(f) New Design Principles

Miller and Swensson (1995,3-4) outline that unlike the hospitals which were funded by municipal governments and charitable organizations, or by religious establishments, twentieth-century hospitals were identified as 'profit-making'; since, physicians or healthcare providers, as the authors define, have the control and authority on the health system. They go further, in fact. They give information about private and teaching hospitals which are in relation with medical schools and universities. The latter, yet, needs both wealthy patients to support their budget and patients who could not afford to pay, to keep on their research and teaching activities.

Several changes in the healthcare system and industry had come into existence by theof 1980's. The first one, as Miller and Swensson (1995, 4, 11) mention, is the emergence of an economic crisis which caused decline in insurance values, but also increase in health expenses. Patients therefore gained importance as health needers who pay for their health problems. The second change, in the architectural sense, was to leave the institutional character of traditional hospitals aside, in favor of the individual who up to that time was considered an insignificant entity in the overall picture. The aim, from this point on, was to create comfortable and friendly residential environments in hospitals, quite unlike traditional institutional ones. Along with this, another aspect that predominated in later decades was to accept the concept of 'consumerism' in the field of healthcare, (Kliment, 2000, 4). This author goes further with the fourth one that hospital organizations aimed to cut down lengths of stay in hospitals; so that, ambulatory care, together with a wide range of specialised clinics, gained importance. He emphasizes the utmost importance of developing high-quality environments with efficient solutions by architects to support management facilities.

Kliment (2000, 4-7) summarises the missions of architects in adapting to these changes. He says that architects, as 'problem solvers', should strive to improve the quality of the environment for both patients and staff in hospitals. Moreover, that their solutions also have to be efficient in order to be compatable with healthcare management processes. They can, consequently, create healing environments to improve human relations between patients and health providers as well as to support the quality of care. As is the case to decrease anxiety and fear, the major aim should be to instigate a sense of "comfort, safety, respect and dignity", as basic human demands. Millman and Smith (2003, 50-53) also state that, in recent years, "Design embraces aesthetics, reflected in the use of materials, detail design and the use of both natural and artificial light, form and colour. It must also embrace functionality, providing an environment that enables effective and efficient healthcare to be delivered in a building that performs well technically".

Catananti, Damiani, and Capelli(1998) focus on several building requirements such as for site planning, for architectural design, building materials and furnishing, heating, ventilation, and air-conditioning systems, in order to satisfy the safety and comfort needs of users in these unique buildings. According to the authors, flatter sites should be preferred and those sites in earthquake-prone areas should be avoided; preferable would be easily-accessible sites in urban areas, for example, to allow easy, rapid access to the facility; and the site should have potential to allow the building to grow in future. In the architectural sense, considerations on ventilation can be to reduce outer wall area to minimise heat transfer from outside to inside or vice versa, or to decrease internal distances from windows or openings to gain more and more natural ventilation and light. They continue this discussion with examples suitable building shapes for health facilities. Horizontal and dispersed buildings linked together are preferred for hospitals with capacities of 300 beds and lower —low density—due to low construction and management costs; while, monolithic buildings are suitable for hospitals with greater capacity—high density—. The authors also mention that "The internal space dimensions and distribution have to cope with many variables, among which one can consider: functions, processes, circulation and connections to other areas, equipment, predicted workload, costs, and flexibility, convertibility and susceptibility of shared use."

Millman and Smith (2003, 50-53) explain the new term, 'patient-centered care', as follows:

> The traditional way of organising hospitals into discrete departments and moving the patients around had been rethought. The patient is placed at the centre of clinical activity, supported by small teams of multiskilled staff and provided with decentralised diagnostic, therapeutic and support services close to or at the bedside, utilising standard care protocols and state-of-the art medical technology and information technology (IT).

The authors go on further to state that healthcare may have radical changes in future in terms of building forms and content. Accordingly, many more patients are to be cared for in their home with the help of new information technologies and improvements in biomedicine, while, hospitals' significance still will be kept on as high-tech environments serve patients with specialist equipment and skills. The hospital will be "the setting for emergency care with admission, observation and assessment, together with the complex diagnosis, interventional treatment and in-patient care". In addition, many healthcare facilities may be linked with the use information technology and tele-medicine by communication networks". They also state the explanation of the hospital in future as follows,

> The hospital of the future may be assembled in a number of different ways, according to the type or range of functions that are provided. Hospital planning may no longer be based on the departments, but rather on multifunctional generic spaces that can be combined according to their function, whether they are unique, repeatable or modular and whether a standardised or customised solution is required. The siting of the new facilities will be an important factor and a return to more urban locations for the larger specialist centres may be desirable. The challenges for the future are great and the

> opportunities are immense. Making the correct choices helps the delivery of healthcare and enhances both the perception and experience of users. Increased expectation demands high-quality design that is both visually stimulating and effective functionally. It also means designing buildings that are easy to clean and maintain and that can adapt to changing delivery models.

Chand (2002, 64-65) agrees on these considerations that hospitals may become acute clinical services for only very ill patients, as well places for housing advances technology with appropriate equipment. The author continues as,

> Changes in clinical practices, brought about by shortages of money and skilled staff, demand enhanced efficiencies in the processing of patients. The process is greatly helped and made safer if key departments are co-located. Small footprints prevent appropriate adjacencies and therefore impose penalties in terms of clinical safety, staff efficiencies and transportation costs. An efficient hospital for the future will require floors with large footprints--say 6,000 to 8,000 square metres per floor, depending on the size of the facility. One sensible design response to facilitate modern health care delivery is to have a fat, squat building rather than a thin, tall one. "Fat" footprints will need clever spatial resolutions for the introduction of natural light and cognitive wayfinding devices.

Jones (2002,42-61) mentions several examples of hospitals in Austria are presented how technology and hospitality can exist together. The extension of the Regional Hospital of Graz is an efficient one. Treatment rooms and operating theatres are located in the new block, while wards, offices and lecture theatres are in the old. The connection is provided by glazed passages in the gap between the two buildings; since, the architect does not want to disturb the old building's back. For the second example, extensions designed for the Regional Hospital of Fürstenfeld became both lively and very responsive to patient demand. The new building is added behind the main one where old rooms are to be used as wards and offices. As the Regional Hospital of Graz, operating theatres and clinics are housed in the new block; and two passages-one for patients and other for doctors- are put into use to link two buildings.

According to Seren (1999, 105) continual fall in the public health investments resulted with an increase in the number of private hospitals in Turkey in the last decade. Several significant problems in the organisation, design and construction stages of healthcare facilities in Turkey have been observed. First, discussions held by other countries in 90's, on healthcare services and design together with the thought of necessary roles of governments on healthcare services, were ignored by Turkey. Second, the sharing of the authority and responsibilities related to the organisation, design and construction of hospitals in Turkey by both Ministry of Health and Ministry of Public Works and Housing prevents the subject from being handled as a whole. Third, insufficient solutions were resulted due to inadequate studies about demands of occupants and functions, and long design and construction periods. In addition, lack of communication among designers, contractors, controllers and users lead to wrong applications. Fourth, even though foreign companies are preferred in healthcare facilities design and construction due to their experience and knowledge, differences in culture and requirements specific to Turkey create problems in use.

The author continues to specify these problems. Although it is given prime importance to the exterior appearence and public spaces, several issues which should be taken into consideration, such as, criterions directly related to patients, hygiene, the situation of patient's bed and examination bed in a room, providing adequate ventilation and light in the space, traffic through diagnostic and treatmet facilities, psychological attitude of patients and its relation with the space, etc. Many imported and expensive finishing materials are chosen, however, due to the wrong selection according to the function, many problems in terms of hygiene and wearing may occur.

Several researches about hospital planning and healthcare facilities have been conducted also in order to improve environmental and patient care quality as well as to achieve technical advancement.(Cunningham,2002, 58-62; Dilouie, 1998,64; Dvoskin, Radomski, Bennett, Olin, Hawkins, Dotson, & Drewnicky, 2002,481-493; Gorman,1998,56-57; Gross,Sasson,Zarhy& Zohar,1998,108-114; Grosskopf, Margaritis, & Valdmanis,2001,83–90; Kazanasmaz,2002; Kazanasmaz,2003,14-23; Kazanasmaz and Düzgüneş, 2004, 213-223).

2.1.2 Factors of Healthcare Design Complexity

In this section are presented the factors of healthcare design complexity under five sub-headings, namely, demand os users, developments in science and technology, environmental quality, obsolescence, and flexibility and expansion.

(a) Demands of users

Miller and Swensson (1995,20,21) state both the expectations of people entering hospitals to be cured or improved, and the reasons for not deciding easily to create humanised, comfortable environment in healthcare facilities. As are mentioned as human needs, demands of patients which are also social psychological needs are deemed to be in conflict with demands of care providers which are related to efficiency. It is identified that nurses prefer circular plan shaped nursing units due to spending more time for each patient than for patients in units with double loaded corridors. In contrast patients require their privacy which is yet avoided in circular type.

In addition, Kliment (2000,4) defining patients as consumers, summarizes that they appreciate the quality and character of the environment which constructs positive feelings about the facility and care providers. Sur (2004,1) also agrees on. As is mentioned by Kliment(2000,4) patients, actually, demand;

- participation in healthcare information and decisions,
- a greater choice of providers,
- a better relationships with their providers
- respect, dignity, compassion and emphaty,
- open and ongoing communication so that their views and wishes are considered and expectations met,
- continuity of care,
- timely, convenient, and reliable services provided in a high-quality and caring environment.

Hence, the perception of the environment by the patients was affected with certain factors such as wayfinding, feeling of comfort and dignity, lighting, appropriate materials, colours and finishes, as Kliment (2000, 4) states.

Linebaugh (2002) also studies nurses' perspectives of factors in the locked psychiatric unit which serve to enhance or hinder healing within this environment to describe the mutual process between environment, patients, and staff.

Marberry (1997) and Malkin (1992, 447-467) on the other hand, mainly focuses on demands of users in the view of wayfinding problem. They, consequently, need to know or understand how they can find the correct way through/inside the facility, or the name of their destination, or appropriate identification signs to reach their destinations.

(b) Developments in science and technology

Several technological developments throughout the design and construction period of hospitals influence the healthcare design according to Kim(2001,112). As is identified certain examples by the author, technological innovations such as mechanical systems for environmental control, elevators, and radiology had profoundly influenced the form of healthcare buildings regarding spatial reorganization. In addition, medical technology, which also affects the functional requirements and the number of inpatients, has been displaying rapid and continuous improvement. Kim (2001,112) states these;

> (1) a satellite laboratory operated totally by robotics
> (2) the increasingly smaller equipment used in clinical labs
> (3) advanced surgical technologies which contribute to shorter stays in inpatient wards.

(c) Environmental quality

James and Noakers (1994,1) express the importance of environmental quality of hospitals in order to create more and more attractive interiors to their patients. In this sense, concerned factors have become as landscape design, finishes and furnishing, the using of work of art. The authors also state some excuse of architects as;

> In hospitals, aesthetic quality leading to some variations in design is tried to be achieved by the handling of spaces and interior design. Many architects offer an excuse for the architectural quality of the hospitals that there remain little time for the aesthetic values while considering the complexity of functional and mechanical necessities of them. However, some spatial effects can be applied in order to bring pleasure to the life of anxious patients and stressful staff.

Whitehouse, Varni, Seid, Cooper-Marcus, Ensberg, Jacobs and Mehlenbeck, (2001, 301-314) conducted a study to understand the effects of a hospital garden on reducing stress, restoring hope and energy, and increasing consumer satisfaction, for a healing environment space for patients, families and staff.The garden was perceived as a place of restoration and healing, and use was accompanied by increased consumer satisfaction. However, the garden was not utilized as often or as effectively as intended. Based on the findings, recommendations for changes were developed to promote better use of the garden. These research findings can be used to guide the future planning, design, building, and subsequent evaluation of garden environments in children's hospitals and pediatric settings.

Kerwin (1997, 37-40) mentions a lighting applied for the Cox Outpatient Center in Springfield, Missouri to increase and to provide a high level of patient, staff, and visitor comfort. The combination of natural light and central space therefore, created a symbol for the beginning of the healing process.

(d) Obsolescence

Obsolescence is defined by Kim(2001,87) as the concept of change and uselessness of a certain aspect within a certain time. It involves the outdated objects, systems in hospitals even though they are in working condition, due to some technological changes and long periods of design and construction.

Kim(2001,88), quoting Bendali-Amor(1993) mentions some causes of obsolescence, and architectural change in hospital design as follows;

> (1) cultural changes which comprise changes in community needs, in health financing and so on;
> (2) technological changes, or more specifically, changes in medical and administrative equipment; and (unbalanced growth)
> (3) the evolution of the medical practice, particularly changes in medical procedures and services.

The author goes on with these reasons;

> (1) medical knowledge(e.g. the miasmatic theory of disease, the germ theory and Lister's antiseptic method);
> (2) technology (e.g., the advent of medical and administrative equipment, and information technology);
> (3)functional requirements (e.g. the mismatch between functional requirements and existing physical systems due partly to poor initial design);
> (4)economy (e.g., hospital competition and changes in payment methods for hospital care, such as much less cost based reimbursement);
> (5) culture (e.g., demographic shifts, and changes in community needs and patient expectations); and
> (6) scientific knowledge from such field as environmental psychology. The failure to catch up with these demands for hospital change leads to hospital obsolescence.

(e) Flexibility and expansion

Miller and Swensson (1995,33-38) state that hospitals should be responsive and sensitive to the marketplace. Thus, flexibility is a demand to adapt the emerging technological improvements in healthcare industry including both physical demands resulting from changes in technology and changes in patient population, patient needs in time. They define flexible design as to create spaces which can be reconfigured quickly, economically and repeatedly. In order to satisfy this issue, in 1960's the concept 'interstitial space' relating to mechanical and electrical components was introduced by Zeidler for healthcare design.

Flexibility which is needed in planning can be achieved with race-track corridors in the facility by adding or modifying spaces easily; however, it often causes several problems in the layout; for example, it causes long walking distances, or difficulty in observation. Flexibility may also be satisfied by finishes which are in high-quality, long-lasting.

James and Noakers (1994,1-3) agree on this subject that successful hospitals depend on how easily they can change and adapt themselves in time. Long-life structures where internal changes including engineering and drainage systems or new ones can be done easily.

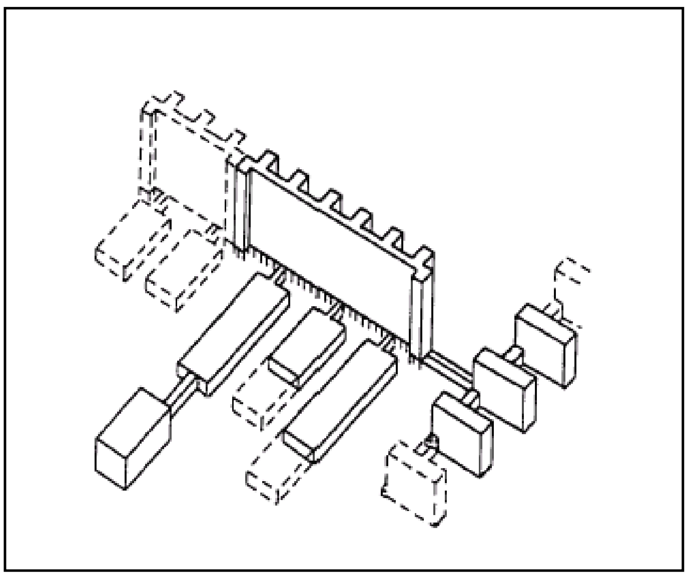

Figure 2.4 The hospital street and the possibilities of change, growth of hospital units [Source:Bendali-Amor, (1993), p.38, originally from Cox and Groves (1981)] (Kim, 2001,109).

Allen (1975, 74-80) mentions that hospitals may be out of date before they are in use because of long construction period, or rapid changes in technology and in equipment. Adaptability therefore is needed to anticipate change. Flexibility may be satisfied by eliminating or reducing the number of some vertical elements, or mechanical shafts. Some vertical elements such as elevator shafts, staircases are practically impossible once constructed so they resist changing. A building may be flexible whether it can grow for future changes. This can be satisfied with corridors reaching to the outer wall for extending outside in future. This leads to the expansion of that space. (Figure 2.4).

Sharon (1975,135) also defines terms flexibility, expandibility and time factor respectively. The third factor is important for construction of huge hospital buildings since they need long periods of time. As is related with the organization of design-phase alternatives, Özgüner (1975,96) defines the concepts flexibility and adaptability as a “twin sister design factor”, since some spaces in hospitals may be obsolete before it is accommodated.

2.2 Principal Departments of the hospitals

Cox and Graves (1981, 72) mention three categories of accommodation in a hospital, namely medical services, medical support, and general support services. The first one includes diagnosis and treatment facilities--outpatient clinics, accident and emergency, short stay wards related with accident and emergency, the operating department, and radiotherapy--for patients. The second one is related with the medical services functionally, involving wards such as the pharmacy, central sterile supply, and medical library. The last one, general support services, are responsible for general administration, the supply of food, stores, the maintenance of heating, lighting and energy services.

2.2.1 Medical services

Medical services are generally involves three kinds of facilities serving both inpatients and outpatients; namely, inpatient facilities, outpatient clinics, and accident-emergency departments.

(a) Inpatient Facilities

Miller and Swensson (1995,47-48) recommends a few items about inpatient facilities. For example, the conversion of patient rooms to intensive care rooms with adding glass at the corridor wall, the separation of visitor elevators and service elevators, placing patient rooms in pods available for easy visual contact by monitoring.

The orientation is another important item in planning. Gainsborough and Gainsborough(1964, 129-130), state that long open wards should be situated on North-South axis because the wards can receive sunshine on both faces of the block. In smaller units, however, it is better to place wards on East-West axis where patient areas facing South. Orientation is also determined with the disposition of the site considering the position of main and service roads. The author goes on. The main aim is to receive adequate daylight and insolation in patient areas.

Catananti, Damiani, and Capelli (1998), mention space requirements in inpatient facilities as, 6 to 8 square metres (sqm) per bed for open wards, including circulation and ancillary rooms; 5 to 7 sqm/bed for multiple bedrooms and 9 sqm for single bedrooms according to Decree of the President of Ministers Council (1986) and American Institute of Architects Committee on Architecture for Health (1987). (Figure 2.5).

(b) Outpatients Clinics

As is defined by Cox and Graves (1981, 72-73), outpatients department which is composed of various clinic sessions is for home based patients' diagnostic and treatment facilities. One important item that should be considered is mentioned by Cox as "Out-patients should not have to pass through any other part of the hospital to reach the department." so if it is entirely at the street level, it will be a great advantage for patients, especially ones having difficulty in moving. The department should easily reach by people both coming with vehicles or as pedestrian. If there are some public transport routes, the department with a separate entrance should be close to them. In a health centre, people follow the sequence like this; reception, registration, waiting, and consultation. People waiting are generally visitors and may not want to accompany patients. Therefore, waiting places for patients directed to clinics could be situated to adjoin the clinic. So, the scale of the general waiting place can be reduced. The authors go on further. The department should be easily- accessible to radio-diagnostic facilities and/or physiotherapy. (Carpman and Grant, 1993, 65-135). (Figure 2.6)

Catananti, Damiani, and Capelli(1998) also give information about space requirements of, for example; general-purpose examination rooms as 7.4 sqm; special-purpose examination rooms and treatment rooms as 11 sqm.

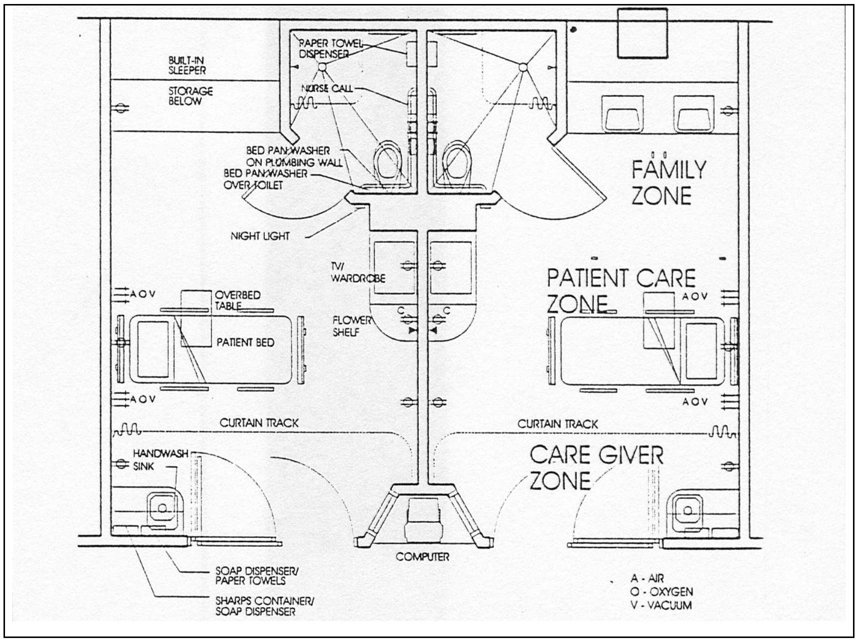

Figure 2.5 An example of a patient room plan in a hospital.
(Kliment, 2000, 16).

(c) Accident & Emergency

This department, as Miller and Swensson (1995, 47) with inclusive of emergency and ICU/CCU, trauma and primary care, shares central registration with all all other services. Its registration facility is not seperate from the main hospital registration.

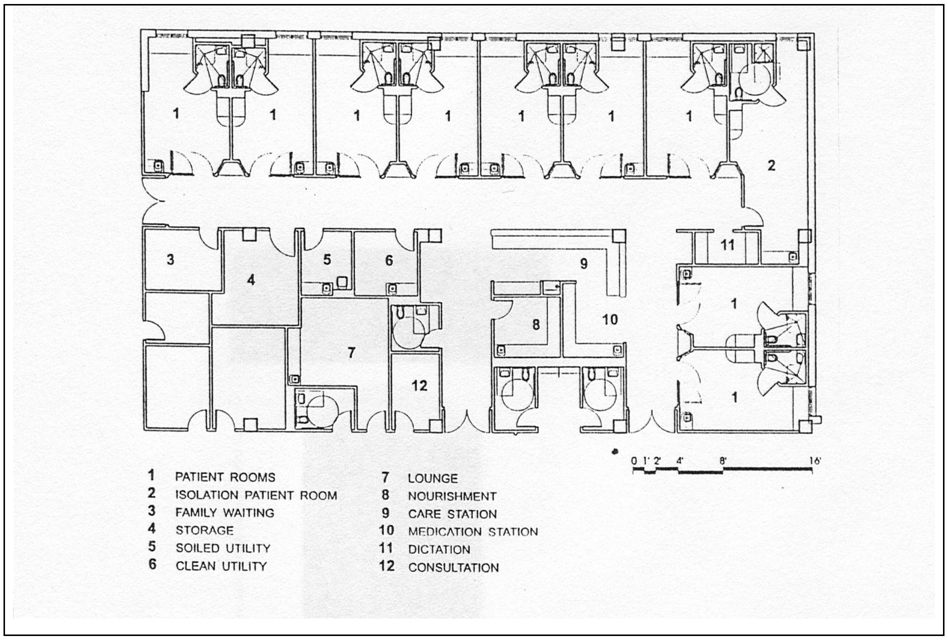

Figure 2.6 A clinical decision unit floor plan at Methodist Health Center in Houston, Texas. (Kliment, 2000, 17).

Cox and Graves (1981, 75-77), describe the accident and emergency department as a space where people goes when sudden illness happen; with inclusive of small waiting space, a consulting room, treatment place, small operating theatres and a few beds. It should be accessible from the general waiting space and the lobby, that the main examination area, diagnosis and treatment areas could be used. The internal relationships have particular importance in emergencies, so suitable circulation space should be designed to easy movement of patients on trolleys (gurneys) or injured patients should not be disturbed more.

2.2.2 Specialistic diagnostic & treatment services

Movement within and between diagnostic and treatment services in hospitals need careful planning to attain suitable work flow patterns. Kliment (2000, 12-14) explains the importance of movement in a hospital. Movement of people and goods can be effective in time and budget management. Minimum distances between destinations are required to be efficient in time and be economic. After space requirements and arrangement of functions are established, circulation patterns including separation of public traffic, service traffic and the movement of goods. Clear and easy patterns of circulation are desired within and between departments.

Specialistic diagnostic and treatment services include operating department, radiology, laboratories, physical medicine, intensive care units which are explained below.

(a) Operating Department

Kliment (2000, 79-84) defines operating department as serving for treatment of both outpatients and inpatients in the same operating suite; so, movement in this department has

also gained importance in the view of users--patients, medical staff, visitors, etc. Inpatients for example, enter the area from the inpatient nursing units, reach to a holding area for surgical preparation, then to the operating room. Medical staff, on the other hand, wear their sterile cloths in a dressing room and reach the operating room through a lounge and a perimeter corridor. After the operation, they speak with the patients' family in a separate consulting room. (Cox and Graves,1981,72-89)**.** Dharan (2002,79-84) also gives information about environmental controls in operating theatres against surgical-site infection.

Kliment (2000, 84) adds the relationship of this department with others as;

> Patients areas, such as the emergency department, the cardiovascular intensive care unit, the intensive care unit, and patient rooms, require direct horizontal or vertical access to surgery. This layout accomodates the safe and rapid transport of patients. Support areas, such as pharmacy, laboratory, respiratory therapy, and central sterile processing and housekeeping services, should have access to surgery through nonpublic and nonsterile corridors...Central sterile processing requires either horizontal or vertical adjacency to surgery to transport sterile supplies and instruments rapidly and directly.

Catananti,Damiani, and Capelli (1998) analyse this department into two main areas; namely operating rooms which is approximately 33.5 sqm and service areas. Besides, there are rooms for endoscope facilities, rooms for waiting patients, recovery rooms from anaesthesia.

(b) Radiology or Imaging

Kliment (2000, 27-28) explains patient and work flow of imaging facilities in a health care center. Various types of patients may reach to an imaging center from different sources such as from inpatient units or other treatment departments by wheelchairs or by walking, and outside the hospital as outpatients. The separation of these two circulation patterns is needed generally. The process of image generation, analysing images and reporting results may intersect the flow of patients. The department is highly related with the other treatment departments, even some—for example, emergency department— has stronger relationships.

Miller and Swensson (1995, 47) mention general properties of this department. They say that work areas for staff are separated to decrease conflict between movement of patients and staff. They also agree with the predefined idea by the preceding author that this department is situated close to the emergency department. Cox and Graves (1981,78) recommends a suitable waiting space with a welcoming reception office, and easy access to outpatients and emergency departments. It is also necessary that trolley access should be satisfied conveniently.

Catananti,Damiani, and Capelli (1998) give information about diagnostic radiographic rooms of either 23 sqm or 16 sqm, dark rooms of 5 sqm, waiting area, viewing area for reading films and reporting. The wall thickness of a radiology unit is approximately 8 to 12 cm thick poured concrete or 12 to 15 cm thick bricks.

(c) Laboratories

Miller and Swensson (1995,46) mention modular arrangement of laboratories for future flexibility. These areas are close to materials management areas for supply delivery, and sometimes surgery. According to Kliment (2000,20-23) processing units in laboratories may not be accessible to patients and not occupy large areas. Patients can only access in the specimen collection area; especially ambulatory patients should easily access not only there but also the space for reception,and waiting. The author also adds that this area may be away from other services; however, transportation of specimen and call for results are important in the support service of this department.

(d) Physical Medicine

Miller and Swensson (1995,46) states that physical medicine is situated on the main level where outpatients can easily access. Kliment offers that it is necessary to locate this service near elevators where both inpatients and outpatients can reach. Kliment (2000,98) mentions that the size and configuration of this department is related with the workload which is dependent on the number of inpatient and outpatient visits. This department is related to nursing units such as orthopedic, cardiac, or neurological etc.

According to Cox and Graves (1981,78), this department is highly related to outpatient department as it should be easily and directly accesible. Inpatients can reach to this areas easily, as well, without passing out-patients' area.

(e) Intensive Care Unit

As is explained by Cox and Graves (1981,85) and O'connell and Humphreys (2000,255–262) this department which gives highly skilled and concentrated care to patients is generally located near to the operating department and/or accident and emergency unit.

This unit is also analysed by Society Of Critical Care Medicine (1988,7) that it is recommended to be in a distinct area in the hospital so, no direct or through traffic can flow from the other departments. It is better to locate this area near to the emergency department, operating room and radiology department by a direct elevator travel.

2.2.3 Medical support services

Medical support services have different departments such as pharmacy, central sterile supply which are described in this section.

(a) Pharmacy

A general hospital is generally served by one pharmacy unit which involves whole pharmaceutical products, sterile and non-sterile ones. (Cox and Graves,1981,87). As is mentioned by Miller and Swensson (1995,46) users of this unit—outpatients and inpatients— is combined to minimise the traffic flow. Pharmacy is generally near to material management functions together with a direct access control, according to Kliment (2000, 128).

(b) Central Sterile Supply

This unit is for material which needs sterilisation before any operation or process, and some needs the same sterilization process after use. (Cox and Graves,1981,87). It has three sub-sections in order to satisfy the work flow. It is, on the other hand, necessary to locate this department close to the operating department; either above/below surgery or adjacent to surgery. Kliment (2000, 128).

2.2.4 General support services

General support services have different departments such as catering (food supply), linen services which are described in this section.

(a) Catering (Food Supply)

This department serves both patients and personnel by supplying activities for food, beverages and nutrition in the hospital. Food production methods, the size of equipment, the storage area inside and hours of operation may determine the work load and the capacity of the department. Kliment (2000, 110-111). Miller and Swensson (1995, 46-47) mention the necessity to locate food supply department involving one central kitchen in a place to achieve the most efficient inpatient service. Cox and Graves (1981,88) state the different ways in delivery of food to patients such as; by a bulk container with heated trolley and then to serve meal on plates. It is accepted that this is the most efficient and simple method.

(b) Environmental Linen

Kliment (2000, 118) mention about this service, which may involve a room for receiving soiled linen, storage area for clean linen, mending area and handwashing area, as :-

> The environmental and linen services department is responsible for maintaining a clean and sanitary environment in the hospital, including floors, carpeting, tile, drapery, windows, lights, vents, and upholstered items. This department is also responsible for furniture moves, conference and classroom setups, replacement of patient room furniture, and trash collection.

2.3 Design efficiency in Inpatient care facilities

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

2.3.1 The Size and organization of Nursing units

Alden (1969,89-90) states that hospital consultants, architects, and managers generally consider the size, shape and components to satisfy hospital efficiency. Although various structural shapes--single corrdior, double-corridor, circular or triangular shapes-- have been applied to increase hospital efficiency, the size of these units have gained importance. The question asked to hospital consultants what size nursing units you prefer, two-thirds of all recommends ones with 40 beds and more; while the rest prefers larger units.

Some advantages of smaller nursing units may be summarised according to Alden (1969,91) as, (1) the distance between nursing station to the patient beds becomes no more than 90 feet; (2) the ease of nursing operation for the head nurse since she/he may not give high-quality care efficiently to more than 30 patients; (3) a qualified and personalised nursing unit is achieved with 20- to 25-bedded unit with single rooms. (4) in larger units, the large amount of activities and heavy traffic may occur between patient and service rooms; so this may cause confusion.

Alden (1969,92) also explains several hospital consultants' opinions about medium-size (40 to 50 beds) and large (50 to 60 beds) nursing units. In the former, staffing seems to be easy, it is flexible, and economical for the use of personel; however, in the latter, it is economical to construct, it needs fewer nursing stations and executed economical operations.

Aydın (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 to 30, as the author mentions. She goes on further. Spaces excluding the patient bed rooms have standard functions similar among most of the hospitals except some specialistic units such as units for children, women and the units of maternity. These are nursing station, doctors and nurses' offices, toilets and baths, laboratory, and day rooms.

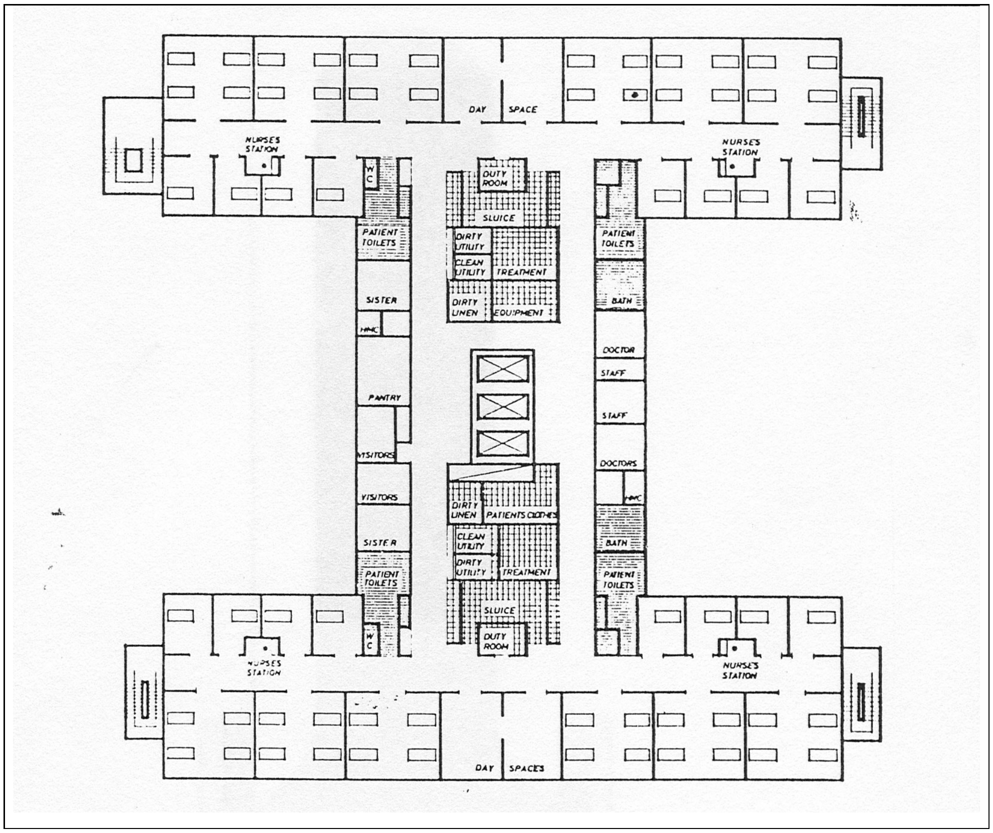

Figure 2.7 A single-corridor ward in Nevill Hall Hospital, Abergavenny. Sir Percy Thomas & Son. (Gainsborough & Gainsborough, 1964, 137).

2.3.2 Plan configurations

Gainsborough and Gainsborough (1964, 137-139, 151,153) mention four types of nursing units as;(1) single-corridor wards with the example of Sir Percy Thomas and Son for Nevill Hall, Abergavenny where 25% of patient rooms are single-bedded, and all rooms can be observed equally from the main corridor (Figure 2.7); (2) double-corridor wards where the whole area is seperated into two spaces as interior and exterior. One of its disadvantages is its higher construction costs; however, its prime advantage is its operational efficiency which is high in this compact type of hospitals. Nursing care is satisfied with high observability of patient rooms by nurses. Its other advantages are stated by the author as “greater flexibility in subdivision of the ward, the ability to design flexible acute care units for a compactly arranged but large enough group of beds, the shorter distances for disposal and supply, and the shorter perimeter and greater conservation of heat.”(Figure 2.8); (3) square wards which have the largest area compared to its perimeter (Figure 2.9); (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,1978,21-32). (Figure 2.10). This type, however, as defined by Miller and Swensson (1995, 38) is less flexible against changes in needs, than other types. The authors also add another type as 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 2.11.

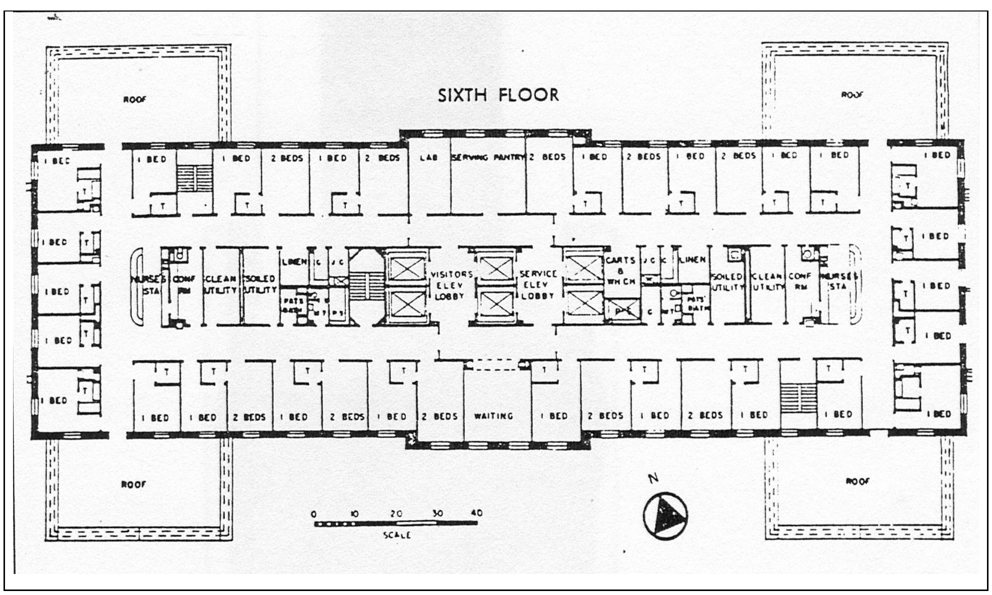

Figure 2.8 A double-corridor ward in Chapel Hill University Hospital, North Carolina. Schmidt, Garden and Erikson and andNorthrup and O’Brien. (Gainsborough & Gainsborough, 1964, 140).

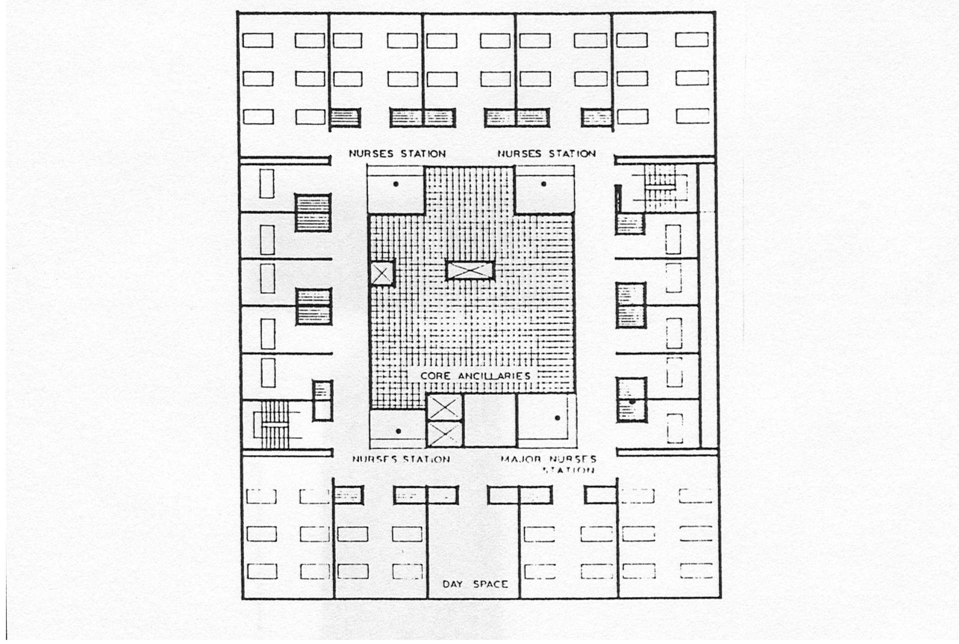

Figure 2.9 A square ward in Whitesberg Hospital.Sherlock, Smith and Adams. (Gainsborough & Gainsborough, 1964, 151).

Kliment (2000, 133-135), beginning with the period in which the influence of church was dominant on the construction of hospitals, mentions the evolution of nursing units which corresponds to the demands of the period. The character of nursing units, in this sense, gained their forms and patterns. As the author continued, construction methods and limits determined the shape of earliest ones. Available maximum structural span and demands for natural ventilation also were predominant factors on nursing unit design. In the light of these basics, the Nightingale Plan type was emerged providing highly efficient nursing care. Technological advances such as steel construction, elevators, and air conditioning were the continuing factors in design. As elevators connect nursing units on vertical orientation, walking distances were decreased with small areas of land.

Some variations in patient accommodation have been observed as multibed versus single-bed room. According to Kliment (2000, 145-147), rooms were shared by eight patients, or six patients or four patients; 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. Hospital managers, however, have become aware of the fact that single rooms can reach higher occupancy percentages; so, they benefit from using single rooms. As the author stated that single patient rooms reach to 100 percent occupancy, multibed patient rooms reach to 80 to 85.

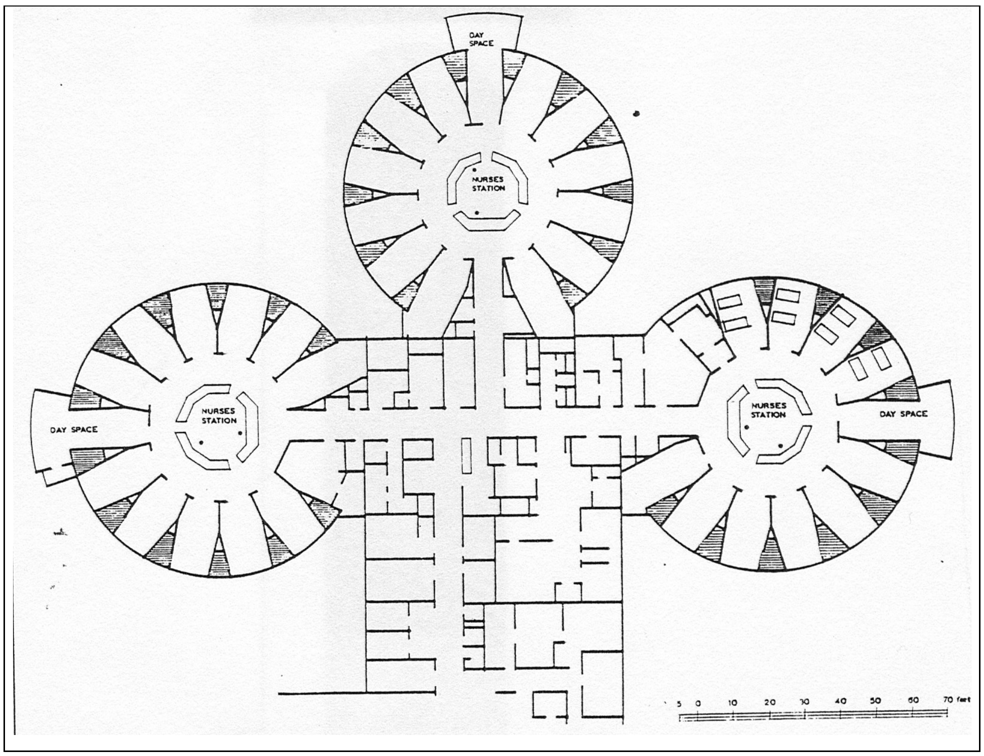

Figure 2.10 A circular ward in Lakeview Hospital, Stillwater. Ellerbe & Co. (Gainsborough & Gainsborough, 1964, 152).

Catananti,Damiani, and Capelli (1998) 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.

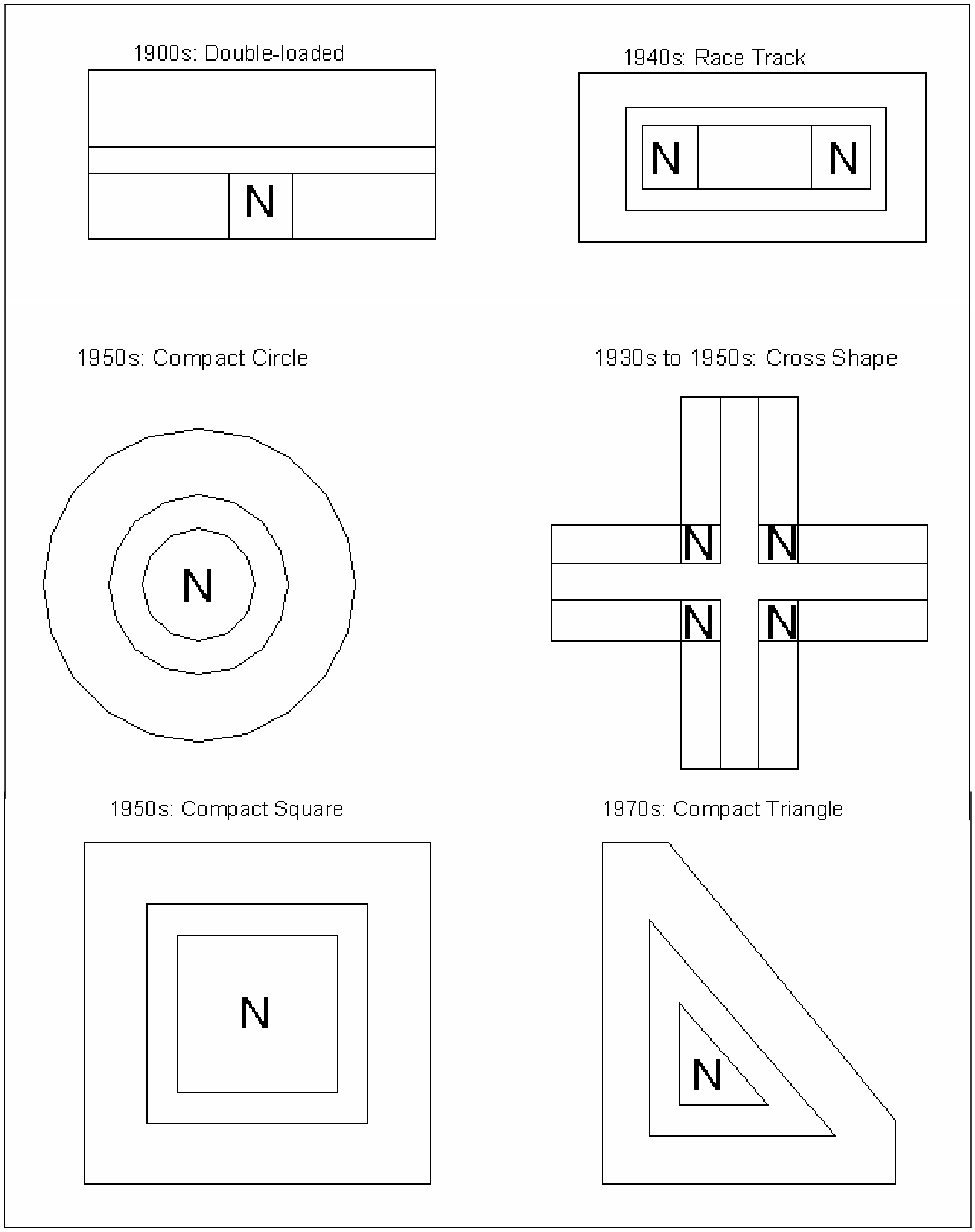

Figure 2.11 Generic plans of common nursing unit forms (Kliment, 2000, 140).

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. The authors also add that

> The space requirements should be at least: 6 to 8 square metres (sqm) per bed for open wards, inclusive of circulation and ancillary rooms (Llewelyn-Davies and Wecks 1979); 5 to 7 sqm/bed for multiple bedrooms and 9 sqm for single bedrooms (Decree of the President of Ministers Council 1986; American Institute of Architects Committee on Architecture for Health 1987).

Özgüner (1975,97) also analyses the healthcare building into three constructional elements as; (1) Spaces--service spaces, circulation spaces, and activity spaces--; (2)Equipment; (3)Structure. This architectural terminology may be different, for example, serving and served spaces, or wet and dry spaces can also be used. While spaces are three dimentional elements, equipment and structures resemble two dimensional elements which are used in architectural design by constructing the relation, juxtaposition, superimposition of these elements. In a study about the growth of a hospital, it is concluded that activity spaces involving patient rooms, waiting spaces and outpatient areas grow relatively more than service spaces involving food service, administration or laundry.

2.3.3 Planning for efficient operation

Miller and Swensson (1995,21) 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 (2000,136), 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 model to satisfy this.

Several studies were conducted about this problem, as the author stated (Kliment 2000,137-138). One is the ‘Yale Traffic Index’ study which is about traffic patterns in many types of hospitals. They analysed 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 suggests 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. This is presented as a format in Figure 2.12.

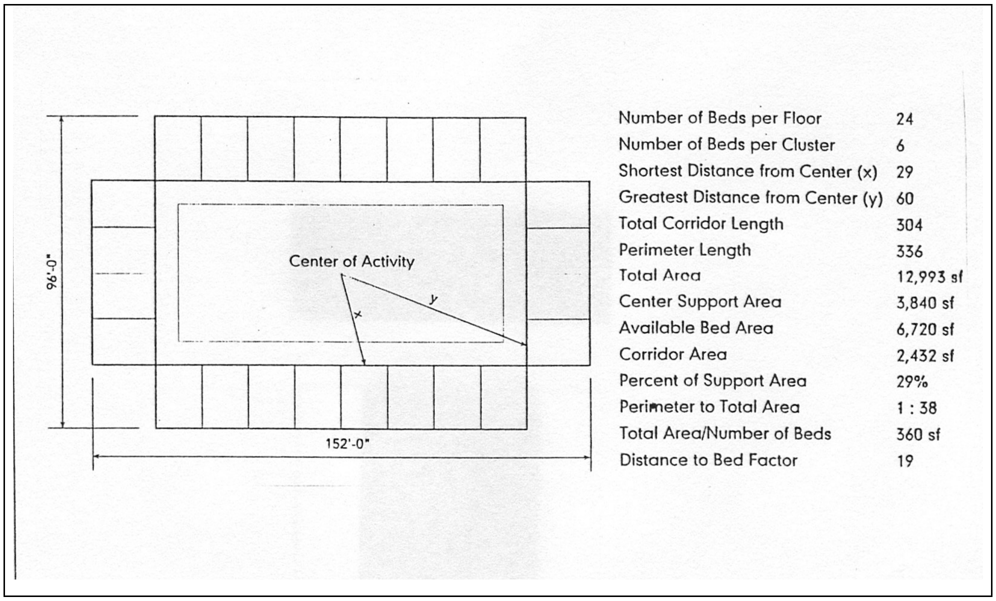

Figure 2.12 Nursing unit analysis format (MPA/BTA). (Kliment 2000,139).

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 seperate 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(1956,146,152) 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. It was then considered to develop statistical techniques to analyse this issue. The main demand to be considered seemed to organise the size of outpatient department relating number of clinics, the number of patient beds, the size of waiting spaces etc. What are the architectural solutions to fulfil required demands effectively, at this moment, seems to be the field of study in operational research. It is also of great importance to analyse the efficiency of hospitals by constructing research methods in relation to several factors such as walking distances, spaced utilised, light intensity, patterns of movement, services *etc*.

(a) Traffic patterns

As is mentioned by Bailey (1956,153), 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. They go on further with two main problems in traffic. In a route between two spaces there is a constant total traffic flow which can be minimised by cutting down walking distances for all users of the hospital. In the second problem, they aim to minimise the traffic density in a certain place at a certain time. To measure density seems to be more difficult than to measure total flow.

To carry out investigations on traffic problems, large number of survers, in general, should locate at certain points to record traffic. As hospitals are large and complex, organised with different local needs and involves variation in organization, this type of survey may not be generalised broadly. Authors suggest not to design bottlenecks or awkward intersecting lines of traffic; however, to consider the relations of lifts, outpatient clinics and visitors.

Clibbon and Sachs (1978,13-20) also presented a research based on a spatial system where patient and work flow is provided, and on its expanding role in health care.Clinical techniques spaces (CTS) are defined as places where the patient goes to for the technique provided. The diaphragm is defined as the band of consulting spaces from the CTS. It can easily be expanded. Three versions of diaphragm is presented which includes examining rooms and offices arranged along a corridor whose internal and external bends allow variations in the sizes and number of rooms.

(b) Single-bed versus multi-bed rooms

As is mentioned by Alden(1969,91), single patient rooms are preferred and recommended among multi-bed patient rooms; however, it is better to accomodate both single ones and multi ones. Bailey (1956,146-157) 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 measured by different factors such as journeys' frequency of occurence, types of journeys, and distances *etc*.

(c) Space around the bed

Bailey (1956,146-157) 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 2 ½ feet [76.20cm]. For beds 3 feet [91.44] in width this gives a minimum distance of 7 feet [213.36cm] between the centres 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.

(d) The net-to-gross area ratios

Hardy and Lammers (1986, 320-321) 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.

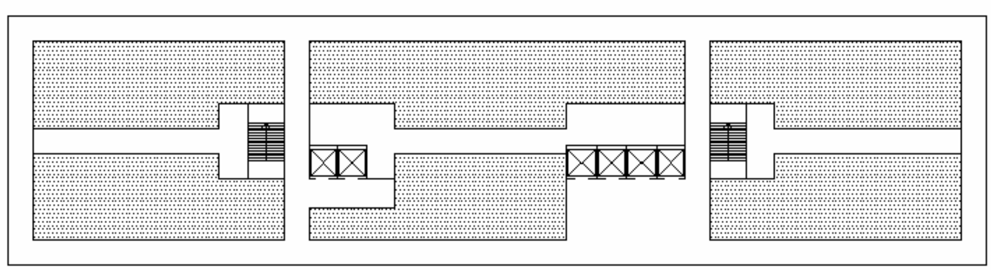

Figure 2.13 Example of design with low net-to-gross ratio.
(Hardy and Lammers, 1986, 322)

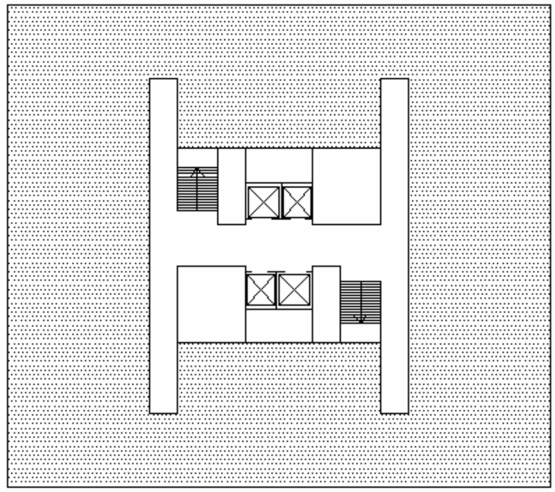

Figure 2.14 Example of design with high net-to-gross ratio. (Hardy and Lammers, 1986, 322)

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 2.13 and 2.14 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.

In the study conducted by the same authors, to examine circulation and construction areas with respect to gross floor area, they have used the following definition of terms:-

- Gross area: total building gross area measured from exterior faces of exterior walls; as related to departments, the gross area forming the department
- Net area: the area of rooms or spaces as measured from inside wall and assigned to functional use by occupants in accomplishment of work related to patient care, research, education or other institutional objectives
- Mechanical area: main boiler room and other mechanical and electrical areas; included in gross areas and excluded in net areas
- Circulation area: entrances, vestibules, corridors, passages, elevators, escalators, stairs, and so on; included in gross area and excluded in net areas,
- Construction area: areas taken by interior and exterior walls, columns, thresholds, doorways, openings in walls,and all plumbing and mechanical chases of which the inside clear area is less than 10 square feet; included in gross areas, excluded in net areas,
- Percentage of net to gross: net/gross X 100.

For these studies, several methods and computer programmes for statistical analyses may be used such as SPSS 10.0 software program for Windows®.

Düzgüneş (2003), on the other hand, constructed a case study report, for buildings, which can be used as a handbook for architects. The form covers descriptive information about facilities, analysis of building sub-systems of as well as aspects information on their site planning and design efficiency. Following this introductory section are covered quantitative features and qualitative features, such as identification of primary, secondary and circulation spaces. The reporter analyses the facility and constructs certain groups of places that belong to each of the three above. Another study conducted by Düzgüneş (1982), is about several indicators for design efficiency of buildings. The author analyzed several housing blocks by using some indicators constructed from building dimensions.

CHAPTER 3

MATERIAL AND METHOD

In this chapter are described the material on which the study was based and the methodology used in evaluating data extracted therefrom. Though there necessarily are some grey areas of overlap, the two are presented under their own respective headings for the sake of clarity. In addition to relevant specifics, that on material also includes an iteration defining the various items of derived and calculated data and the relevance of the various ratios constructed from these as analogue indicators of design efficiency. That on methodology is straightforward and essentially comprises the procedures followed in data compilation and evaluation.

3.1 Material

Subject matter (the population) was defined to be health facilities nominally in the public domain. This decision was based on the findings of a preliminary survey, which showed that, with very few exceptions, most privately-operated ones were lodged in heavily-modified pre-existing buildings originally designed for other purposes. Leaving aside the therefore inherrent difficulty–if not impossibility–of obtaining pertinent study material (plans) on their basic dispositional features, this fact was considered sufficient grounds to treat them as an altogether different population.

To allow of as broad a diversity as possible, no further discrimination was made in the study domain regarding their specialization, if any, so that it was inclusive of pediatric, as well as general hospitals. However, those too localized in regard to the particular administration they served, such as military, municipal and university hospitals were excluded in order to render the study consistent with its overall objective of reaching viably general conclusions.

The study material itself consisted of architectural production drawings, as obtained from the Department of Works (Yapı İşleri Daire Başkanlığı), Ministry of Public Works and Settlement (T. C. Bayındırlık ve İskân Bakanlığı) and the Department of Construction and Real Properties (İnşaat ve Taşınmaz Mallar Daire Başkanlığı) of the Directorate-General for

Health Services (Sağlık İşleri Genel Müdürlüğü) within the Social Security Administration (Sosyal Sigortalar Kurumu). These constituted a sample space of 44 facilities, from which a roughly 33% random sample of 15 units were drawn according to the method described in section 3.2.1. 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 and since, for purposes of this study, it was assumed that all such floors were identical, no effort was made to randomize the selection of floor. Relevant descriptive aspects regarding individual sample elements–each of which were assigned an alpha-numeric label for reference purposes as they were drawn–are summarized under columns A to D in Table 3.1, while schematic representations of their floor layouts, *sans* dimensions, are given in Appendix C, following the same order.

Derived from pertinent production drawings on the basis of dimensions given thereon, were raw data as utilized in calculating the various floor areas deemed of relevance to the study. Also utilized were the room and/or space designations given thereon, which helped establish functional distinction among the various types occupying a given floor. Again, given dimensions were used–this time direct–to obtain cumulative external perimeter lengths of the entire floor as well as internal ones for the various spaces thereon. An iteration of calculated areas is given under section 3.1.1 while that for the functional classification of spaces is given under section 3.1.2, following. Actual values of calculated areas are given in Table 3.1, under columns H to L.

From calculated areas and ancillary data on capacity were obtained a certain number of ratios deemed pertinent analog indicators of constructional design efficiency. A justified iteration of these is provided in section 3.1.3 and their numerical values are given in Table 3.1 under columns N to X.

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 lesser number by competions. Such origins have also been noted in the tabulation mentioned above.

Table 3.1 Data for general information about selected samples

A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
Sample ID	Nursing Unit Organization	Design Origin	Date	Area of Primary Spaces m^2	Area of Secondary Spaces m^2	Area of Circulation Spaces m^2	Net Usable Floor Area m^2 E+F+G	Gross Floor Area m^2	Construction Area m^2	External Surface Area m^2	Number of Beds	Ratio 01 H/M	Ratio 02 J/M	Ratio 03 E/M	Ratio 04 F/M	Ratio 05 G/M	Ratio 06 K/M	Ratio 07 E/F	Ratio 08 E/G	Ratio 09 H/J	Ratio 10 L/J	Ratio 11 L/M	Footprint area of walls M^2
S01	Single corridor	Commission	2002	647.3	311.6	405.0	1363.9	1740.2	376.3	725.1	48	28.4	36.2	13.4	6.5	8.4	7.8	2.1	1.6	0.78	0.4	15.1	310.3
S02	Single corridor	Commission	2002	860.7	232.9	416.0	1508.7	1820.0	311.3	1000.8	76	19.8	23.9	11.3	3.1	5.5	4.1	3.7	2.1	0.83	0.5	13.2	271.2
S03	Single corridor	Commission	2002	1391.1	729.8	731.2	2852.2	3353.9	501.7	1192.5	118	24.2	28.4	11.7	6.2	6.2	4.2	1.9	1.9	0.85	0.4	10.1	249.8
S04	Single corridor	Standardized	1970s	172.6	142.4	109.3	424.4	524.0	99.6	325.8	25	16.9	20.9	6.9	5.7	4.4	3.9	1.2	1.6	0.81	0.6	13.0	97.8
S05	Single corridor	Standardized	1970s	232.4	222.1	206.3	660.9	737.6	76.7	424.2	37	17.9	19.9	6.2	6.0	5.6	2.1	1.1	1.1	0.90	0.6	11.5	73.2
S06	Single corridor	Competition	N/AV	511.1	254.2	470.0	1235.4	1342.8	107.4	688.8	50	24.7	26.8	10.2	5.1	9.4	2.2	2.0	1.1	0.92	0.5	13.8	96.6
S07	Double corridor	Commission	1995	226.6	194.5	197.3	618.5	723.6	105.1	324.9	28	22.1	25.8	8.0	6.9	7.1	3.7	1.2	1.2	0.85	0.4	11.6	70.4
S08	Double corridor	Commission	1990	487.6	294.1	410.1	1192.0	1344.0	152	551.4	50	23.8	26.8	9.7	5.9	8.2	3.1	1.7	1.2	0.88	0.4	11.0	114.3
S09	Single corridor	N/AV	1998	667.0	491.1	569.9	1728.1	2044.3	316.2	1277.4	50	34.6	40.8	13.3	9.8	11.4	6.3	1.4	1.2	0.84	0.6	25.5	312.1
S10	Single corridor	N/AV	1998	115.2	181.1	515.5	411.8	538.4	126.6	289.2	10	41.2	53.8	11.5	18.1	51.5	12.7	0.6	0.2	0.76	0.5	28.9	105.8
S11	Double corridor (with courtyard)	Standardized	1993	767.2	1270.8	918 (courtyard)+ 206.3	2244.3	5243.4	2999.1	1089.9	96	23.4	54.6	7.9	13.2	11.7	31.2	0.6	0.7	0.77	0.2	11.3	1147.2
S12	Single corridor	Standardized	1993	366.7	280.9	430.9	1078.6	1424.0	345.4	577.2	25	43.1	56.9	14.6	11.2	17.2	13.8	1.3	0.8	0.75	0.4	23.0	274.9
S13	Single corridor	Standardized	1984	174.5	204.6	58.3	437.5	588.0	150.5	336.0	25	17.5	23.5	6.9	8.2	2.3	6.0	0.9	3.0	0.74	0.6	12.9	148.3
S14	Double corridor (with courtyard)	N/AV	N/AV	391.8	313.5	594.7+206.2 (courtyard)	1280.1	1765.0	484.9	553.6	30	42.7	58.8	13.0	10.5	26.7	16.2	1.3	0.5	0.72	0.3	18.5	278.5
S15	Single corridor	N/AV	1998	90.2	311.3	268.5	670.0	825.6	155.6	363.0	10	67	82.5	9.0	31.1	26.9	15.6	0.3	0.4	0.81	0.4	36.3	135.6

N/AV: not available

3.1.1 Calculated Areas

These consisted of what were designated as: a) net usable floor area; b) gross floor area; c) construction area; and d) external surface area. The first was obtained as a cumulative figure from those calculated for individual spaces. The coverage of each is briefly described below.

a) Net usable floor area:

This was the area of all interior spaces on a typical nursing floor as calculated from the internal (wall-face-to-wall-face) dimensions given on floor plans. Excluded were door thresholds, balconies, terraces, ventilation and/or utilities ductways and/or shafts, light wells, elevator shafts and similar thru-floor cavities; also excluded were point-bearing elements of structure, such as columns and, where these latter were attached, their projections into the spaces were likewise deducted. No effort was made to further define the accomodation capability/value of the area itself; *i.e.*, whether or not it could actually be put to some germane use.

b) Gross floor area:

This comprised the overall built area of a typical nursing floor, calculated from the external dimensions given on floor plans. Again excluded were all unenclosed projections from wall faces, such as solar control overhangs and fins, balconies, terraces, catwalks, *etc*., as well as projections of attached columns.

c) Construction area:

This was simply the difference of the two areas cited above and, hence, was inclusive of all internal elements that were left out from net usable floor area calculations as well as the foot-print area of external (enclosing) walls.

d) External surface area:

Obtained from the overall external perimeter length and the floor-to-floor height of a typical nursing floor, this was inclusive of all complementary elements installed in wall voids, such as doors, windows and grilles. It being a simple surface measure, no deduction was made for overlaps of wall thicknesses at external corners, as would have been the case if heat loss/gain calculations were to have been made based on it.

3.1.2 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 Düzgüneş (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.

a) 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.

b) 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 bathrooms, 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.

c) Circulation spaces:

Comprised of all spaces not otherwise designated, this category thus 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. It was necessarily exclusive of areas within labeled rooms/spaces intrinsically used for this purpose.

Spaces assigned to each of these categories are identified on the schematic floor layouts provided in Appendix C by their respective legends, while their relative proportions for sample elements are depicted in Figure 3.1. To be noted here is that the deficiency of each bar from unity (100%) thus indicates the area dedicated to the constructional features cited above.

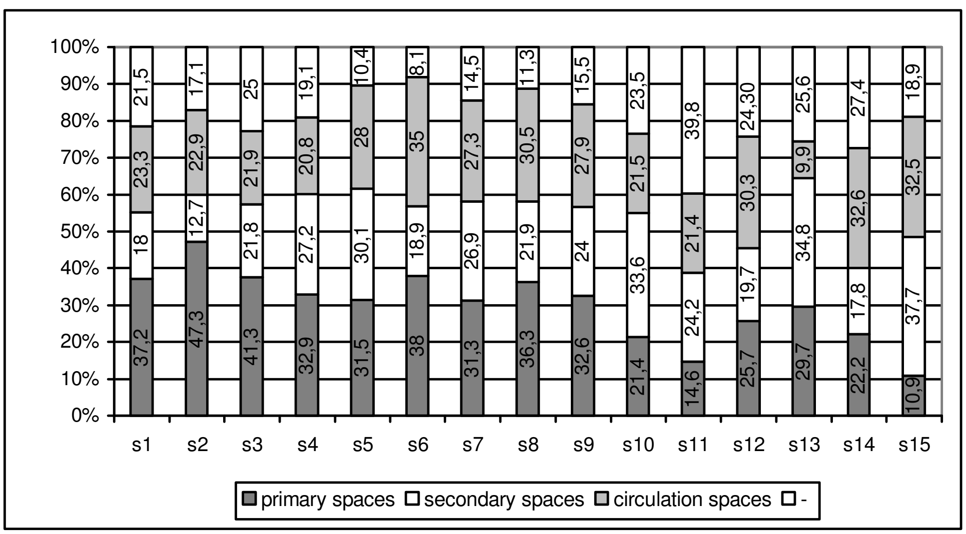

Figure 3.1 Distribution of primary, secondary and circulation spaces for each sample element, with deficiencies indicating areas taken up by constructional features.

3.1.3 Derived Ratios (analog indicators)

These consisted of what were designated as: a) net usable floor area per bed; b) gross floor area per bed; c) area of primary spaces per bed; d) area of secondary spaces per bed; e) area of circulation spaces per bed; f) constructional area per bed; g) ratio of primary spaces to secondary spaces; h) ratio of primary spaces to circulation spaces; j) ratio of net usable floor area to gross floor area; k) ratio of external surface area to gross floor area; and l) external surface area per bed. Ratios (a) to (f) and (l) were constructed on the basis of the bed count for the typical floor under study. The justification for each is briefly described below.

a) Net usable area per bed (ratio 01):

This was considered to be a yardstick indicator of planning generosity, on the assumption that the larger this ratio, the stronger would be the perception of an overall institutional outlook that provides for patient comfort, well-being and care. By extension, it was also considered to be one for the day-to-day working conditions of staff, in terms of both general ambience and accomodation provided for medical treatment facilities.

b) Gross floor area per bed (ratio 02):

In question here was defining a general indicator for both overall design efficiency and economy where, in contrast to ratio (a), a low value would be interpreted as a high level of the former and a low one for the latter concern.

c) Area of primary spaces per bed (ratio 03):

Distinct from ratio (a), this was taken as a direct indicator of the priority values attached to the provision of adequate patient accomodation in the overall space allocation scheme, again on the assumption that the larger it was, the greater would have been the adjunct priority.

d) Area of secondary spaces per bed (ratio 04):

In this case the objective was to define an indicator for the extent of medical and other ancillary support services being provided, isofar as allocated area could be considered as such. In this context, large values would be considered as a positive and low values as a negative feature–of course, relative to ratio (c); values higher than this would be open to interpretation as an overburden in terms of both planimetric efficiency and operating-cum-maintenance costs.

e) Area of circulation spaces per bed (ratio 05):

The outlook here was straightforward in that the ratio would inherrently reflect not only the anticipated traffic density in terms of both patient and staff movement, but also the priority given to obtaining an efficient design in terms of particular floor arrangement preferences so implemented while keeping to normative requirements in effect.

f) Constructional area per bed (ratio 06):

This was considered a latent indicator for the degree of moderation–or extravagance–practiced in creating the building domain–the enclosure as well as the appurtenances deemed essential for performing the functions ascribed to it–within which patients were expected to receive their prescribed treatment(s); hence, an indirect one for the inherrent material cost to them of being in such a domain. While very low values would be open to interpretation as over-economizing at the expense of minimal adequacy, high ones would invite questions on the perspicacity of the designer(s) in achieving the basic integration necessary for any well-balanced product.

g) Ratio of primary spaces to secondary spaces (ratio 07):

Of interest here was defining any inherrent norm that was being observed in this respect; *i.e.* whether or not there happened to be some underlying prescribed value–broad though it may be–on which the allocation of these two kinds of space was based, irrespective of actual hospital type. This would be supported by a marked central tendency while a large dispersion would imply the opposite, that the ratio was dependent on the type of hospital.

h) Ratio of primary spaces to circulation spaces (ratio 08):

This was considered with an outlook similar to that of ratio 05, but in this case, purely on an area basis to more directly reflect any aspiration to space allocation efficiency on the part of the designer(s), again insofar as normative requirements allowed. Adjunct to this was the objective described immediately above for ratio 07.

j) Ratio of net usable floor area to gross floor area (ratio 09):

Giving the broadest coverage, this ratio was taken as the basic indicator for the level of planimetric design efficiency achieved throughout the nursing unit floor, as it was devoid of any and all functional distinctions and thus reflected the essential architectonic outlook if not accomplishment of the design office in question–at least, insofar as this type of building domain was concerned. For simplicity, it is henceforth refered to as the **efficiency quotient**.

k) Ratio of external surface area to gross floor area (ratio 10):

Also called the 'enclosure ratio' by Düzgüneş (2003), here the objective was determining the degree to which concern was shown for at least optimizing if not minimizing the potential load imposed on such surfaces in filtering out the various negative factors of the external environment in order to maintain those within the building domains at acceptable levels; again, insofar as it reflects the architectonic outlook cited for ratio 09, above. Again for the sake of simplicity, it is henceforth refered to as the **compactness quotient**.

l) External surface area per bed (ratio 11):

Though taken on grounds similar to that of ratio 10 above, sought here was the load of such filtration–albeit indirect–imposed on each patient accomodated within the building domains.

Used for preliminary overview, a number of bar-charts were constructed to compare the magnitudes of salient patient-based ratios. Of these, Figure 3.2 shows a comparison of ratio 03 (area of primary spaces per bed) with ratio 02 (area of primary spaces per bed versus gross area per bed); Figure 3.3, a comparison of ratio 04 (area of secondary spaces per bed) with ratio 02; and Figure 3.4, that of ratio 05 (area of circulation spaces per bed) with ratio 02.

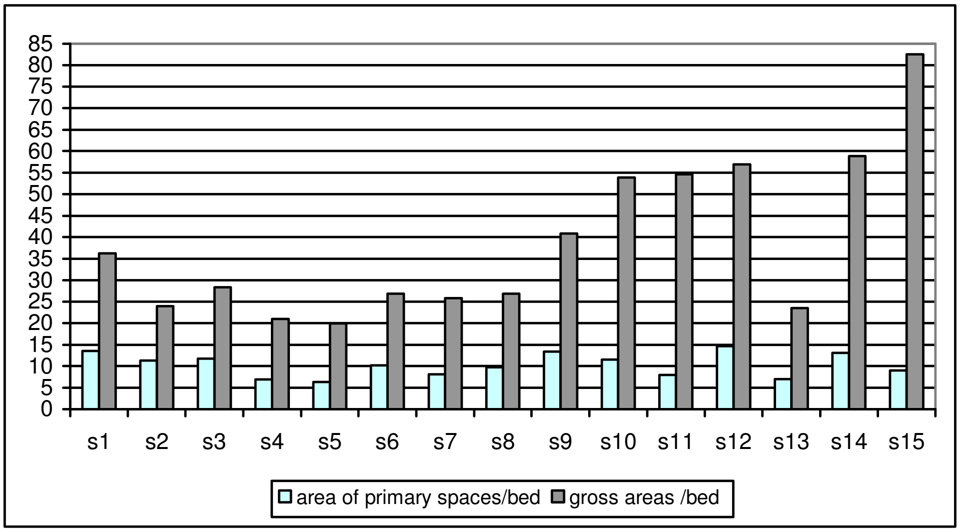

Figure 3.2 Area of primary spaces per bed versus gross area per bed in nursing unit samples.

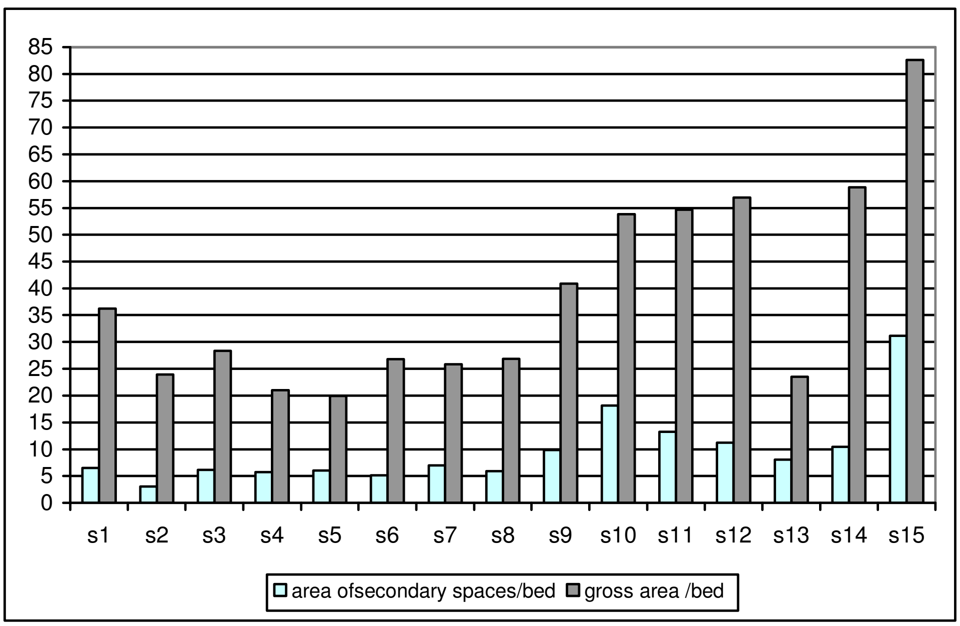

Figure 3.3 Area of secondary spaces per bed versus gross area per bed in nursing unit samples.

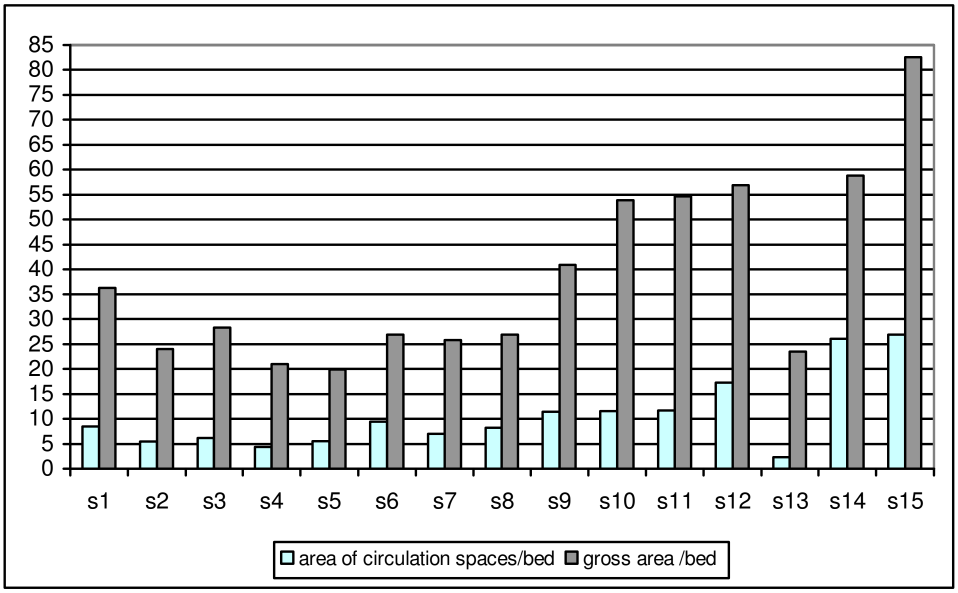

Figure 3.4 Area of circulation spaces per bed versus gross area per bed in nursing unit samples.

3.2 Method

Here is first described the procedure followed in compiling data, obtained from the sources cited in section 3.1, for statistical analysis; it also includes a brief outline of the sampling method. This is followed by a concise definition of the specific statistical method used in conducting the analyses proper.

3.2.1 Sampling Method and Data Compilation

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. Preliminary surveys had shown that, similar to those under private ownership, many of these too were operating in buildings originally designed/constructed for other purposes. As records were not up-to-date in this regard, there seemed to be no way of culling these short of a full field enumeration. Moreover, it was understood from available records that a large proportion of purpose-built facilities were based on the various types of standard Ministry designs–as marginally modified merely to accomodate different siting and environmental conditions. Since the objective of the study was to investigate the planimetric efficiency of facility designs and not their implemented manifestations, no practical end could be realistically served in considering the entirety of such existing facilities, as many would thus be repetitive and so inadvertantly lead to the undesirable result of sampling with replacement. 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 therefrom; 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.

As the first step in the compilation procedure, 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 in section 3.1, dates of design commissioning and completion and the type of nursing unit organization. Data sheets compiled for one of the facilities is provided in Appendix A as an example.

A number of inter-ratio distributions considered relevant to the study were then constructed to serve as a basis for grouping data. Listing them in order, these were the:-

1) distribution of the efficiency quotient (ratio 09) with respect to ratio 03, *i.e.* area of primary spaces per bed;
2) distribution of the efficiency quotient with respect to ratio 04 (area of secondary spaces per bed) ;
3) distribution of the efficiency quotient with respect to ratio 05 (area of circulation spaces per bed);
4) distribution of the efficiency quotient with respect to ratio 11 (external surface area per bed);
5) distribution of the compactness quotient (ratio10) with respect to the efficiency quotient;

6) distribution of ratio 07 (ratio of primary spaces to secondary spaces) with respect to the compactness quotient;
7) distribution of ratio 07 with respect to ratio 06 (constructional area per bed);
8) distribution of ratio 07 with respect to ratio 11(external surface area per bed);and
9) distribution of ratio 08 (ratio of primary spaces to circulation spaces) with respect to the efficiency quotient;
10) distribution of the efficiency quotient with respect to nursing unit organization (single- and double-corridor); and
11) distribution of the compactness quotient with respect to nursing unit organization (single- and double-corridor).

Table 3.2. Areas of primary spaces per bed (ratio 03), ranked in ascending order, with their corresponding efficiency quotients.

Sample ID	Ratio 03	Efficiency quotient
S05	6.2	0.9
S04	6.9	0.8
S13	6.9	0.7
S11	7.9	0.8
S07	8.0	0.8
S15	9.0	0.8
S08	9.7	0.9
S06	10.2	0.9
S02	11.3	0.8
S10	11.5	0.8
S03	11.7	0.8
S14	13.0	0.7
S09	13.3	0.8
S01	13.4	0.8
S12	14.6	0.7

Table 3.3. Distribution of efficiency quotients with respect to ratio 03.

	Group 1 5.9-8.9	Group 2 9.0-12.0	Group 3 12.1-15.1	ΣX_i
	0.9	0.8	0.8	2.5
	0.8	0.9	0.7	2.4
	0.7	0.9	0.8	2.4
	0.8	0.8	0.8	2.4
	0.8	0.8	0.7	2.3
ΣX_j	4.0	4.2	3.8	12.0
N	5	5	5	15
X (mean)	0.80	0.84	0.76	0.80
s_x (standard error)	0.032	0.024	0.024	
s^2 (variance)	0.005	0.003	0.003	
V (coefficient of variation)	8.84 %	6.52 %	7.21 %	

For distributions 01 to 09, sample elements were first ranked in ascending order according to the factor ratio, against which values for the corresponding variant ratios were also given. Classes of relevant interval were then defined for the factor ratios under which variant ratios were accordingly grouped and their statistics (group means–each with its standard error–and variances) given. Included here were coefficients of variation to enable preliminary comparisons regarding the groups. Tabulations for the first case cited above are given in Tables 3.2 and 3.3, respectively, as an example, while those for the remaining distributions have been relegated to Appendix B in order to hold the volume of the main text to reasonable size.

3.2.2 Data Analysis

Three different types of statistical investigation were found necessary to arrive at tenable results regarding the data and the various analog indicators derived therefrom; namely, two-sample Student's t-tests; Regression Analyses (RegAn); and single-factor Analyses of Variance (ANOVA);. The specifics of their applications are succinctly described below.

(a) Student's t-tests

These were done on a two-sample basis assuming unequal variances for distributions 10 and 11 listed in section 3.2.1, to make an initial determination of whether or not any differences to be observed in subsequent analyses regarding the two principal quotients–efficiency and compactness–could be attributed to distinctions in plan organization at a prescribed 5% level of significance ($\alpha = 0.05$).

(b) Regression Analyses

These were linear analyses performed to determine the level of dependency among key elements of derived data that could have become obscured in the construction of the various ratios subsequently used as analog indicators. Thus analyzed were the regressions of circulation spaces and secondary spaces on primary spaces and the regression of net usable area on both primary and secondary spaces. As, when scatter plots were made, there was a distinctive outlier for the regression of secondary spaces on primary spaces, a second analysis was conducted for this with the outlier disregarded.

(c) Analyses of Variance

Single-factor ANOVA was conducted on the grouped data of distributions 01 to 09 listed in section 3.2.1 to determine whether or not treatments resulted in any differences among sample elements at a prescribed 5% level of significance ($\alpha = 0.05$) in regard to the various factors being considered. Null hypotheses were subjected to F-tests according to results of ANOVA tables constructed thereon. Calculations these tests entailed were done by the author using SPSS software from MicroSoft®. For simplicity, no correction was made for discrepancies in group size.

CHAPTER 4

RESULTS AND DISCUSSION

In this chapter are presented the results obtained from the various statistical analyses described in section 3.2.2, in the order listed therein, followed by a discussion of these with respect to literature and investigation objectives. The two aspects are treated under discrete headings so as not to disrupt continuity.

4.1 Results

The results regarding each type of analysis are presented under dedicated sub-headings, with brief interpretations of their immediate implications regarding the issue in question. For Analyses of Variance, each result is introduced by an expanded statement of the null hypothesis.

4.1.1 Two-sample Student's t-tests

The two tests conducted to determine whether or not sample elements having distinctively different planimetric configurations could be considered as belonging to one and the same population where their respective efficiency and compactness quotients were concerned so that subsequent ANOVA would not reflect any original bias in this regard showed that there was no difference among the groups in question at the level of significance prescribed. In other words, neither quotient showed any difference more than what could be attibuted to chance alone, regardless of whether their plans were of the single- or double-corridor type.

The distribution of the efficiency quotient with regard to the two factors and a summary of the test results are given in Tables 4.1 and 4.2, with those for the compactness quotient, in Tables 4.3 and 4.4, respectively.

Table 4.1 Distribution of efficiency quotient with respect to their plans.

Single corridor	Double corridor
0.8	0.8
0.8	0.9
0.8	0.8
0.8	0.7
0.9	
0.9	
0.8	
0.8	
0.7	
0.7	
0.8	

Table 4.2 Two-sample Student's t-tests for efficiency quotient, by plan types.

	Variable 1	Variable 2
X (mean)	0.8	0.8
s^2 (variance)	0.004	0.007
Observations	11	4
Hypothesized Mean Difference	0	
df	4	
T Stat	0	
P (T≤t) one-tail	0.5000	
t Critical one-tail	2.1318	
P (T≤t) two-tail	1.0000	
t Critical two-tail	2.7765	

Table 4.3 Distribution of compactness quotient with respect to their plans.

Single corridor	Double corridor
0.4	0.4
0.5	0.4
0.4	0.2
0.6	0.3
0.6	
0.5	
0.6	
0.5	
0.4	
0.6	
0.4	

Table 4.4 Two-sample Student's t-tests for compactness quotient, by plan types.

	Variable 1	Variable 2
X (mean)	0.5	0.325
s^2 (variance)	0.008	0.009
Observations	11	4
Hypothesized Mean Difference	0	
df	5	
T Stat	3.1850	
P (T≤t) one-tail	0.0122	
t Critical one-tail	2.0151	
P (T≤t) two-tail	0.0244	
t Critical two-tail	2.5706	

4.1.2 Regression Analyses

The results of these analyses, as cited in section 3.2.2.b are presented here separately, as they were considered to merit individual interpretation. Thus, for:-

(a) The regression of circulation spaces on primary spaces

It was evident from the scatter plot of Figure 4.1, based on the paired values given in Table 4.5, that there was very little coherence between the dependent and independent variables considered to support any meaningful relationship among them.

Table 4.5 Distribution of variables, area of primary spaces and circulation spaces.

Sample ID	Area of Primary Spaces (X)	Area of Circulation Spaces (Y)
S01	647.3	405.0
S02	860.7	416.0
S03	1391.1	731.2
S04	172.6	109.3
S05	232.4	206.3
S06	511.1	470
S07	226.6	197.3
S08	487.6	410.1
S09	667.0	569.9
S10	115.2	515.5
S11	767.2	206.3
S12	366.7	430.9
S13	174.5	58.3
S14	391.8	594.7
S15	90.2	268.5

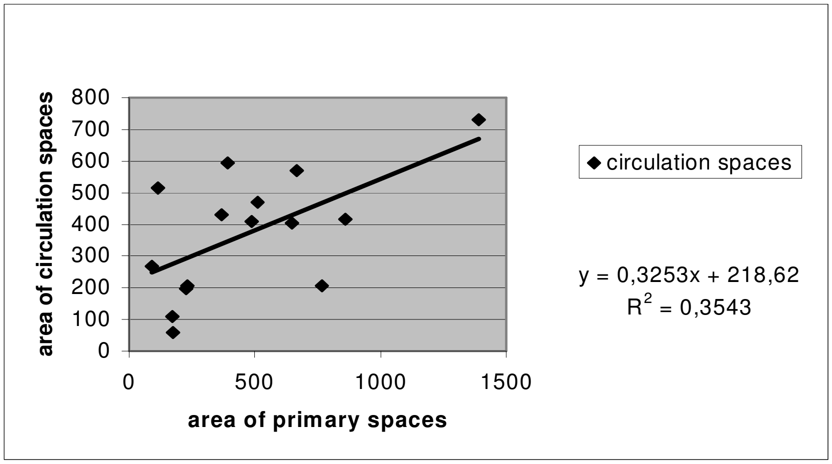

Figure 4.1 A scatter plot and least squares line for the regression of the area of circulation spaces on the area of primary spaces.

This was borne out by the low value of the regression coefficient (R^2), determined as 0.3543. Though not to be totally disregarded, there seemed little cause to suspect that it would create any effective bias for the ANOVA in which they were used.

(b) The regression of secondary spaces on primary spaces

The initial scatter plot of Figure 4.2–as derived from the paired values given in Table 4.6, having an outlier due to sample element 11, also gave a very low value of 0.3531 for R^2, although the remaing 14 elements appeared to indicate quite the opposite. When this outlier was eliminated from the sample to result in the pairs of Table 4.7 and the corresponding scatter plot of Figure 4.3, a much stronger positive relationship was seen to exist between the two variables in question, though at a lesser rate–as evidenced by a high value of R^2 at 0.6590 and a slightly smaller value for the gradient of the regression line: 0.4890 for the former versus 0.3429 for the latter. In result, it was only reasonable to assume that a large number designs indicated a distinct but modest concern in establishing–consciously or not–a marginal balance with regard to the allocation of overall usable space on the nursing unit floor for these two functions.

Table 4.6 Distribution of variables, area of primary spaces and secondary spaces.

Sample ID	Area of Primary Spaces (X)	Area of Secondary Spaces (Y)
S01	647.3	311.6
S02	860.7	232.9
S03	1391.1	729.8
S04	172.6	142.4
S05	232.4	222.1
S06	511.1	254.2
S07	226.6	194.5
S08	487.6	294.1
S09	667.0	491.1
S10	115.2	181.1
S11	767.2	1270.8
S12	366.7	280.9
S13	174.5	204.6
S14	391.8	313.5
S15	90.2	311.3

c) The regression of net usable floor area on the area of primary spaces

It was immediately evident from even the scatter plot of Figure 4.4, based as it was on the paired values given in Table 4.8, that there was a marked coherence between the dependent and independent variables considered, which supported the existence of a strong relationship among them with a distinctly high rate of dependency. This was borne out not only by a high R^2 value at 0.9009, but also by the numerically large gradient for the regression line at 1.897. In other words, for every unit increase in area allocated to patients, overall net floor area increased nearly two-fold in almost all sample elements; a result which in itself indicated serious consideration being given in the designs to obtain as much of this area as the building programme allowed without too great a concession to constructional features.

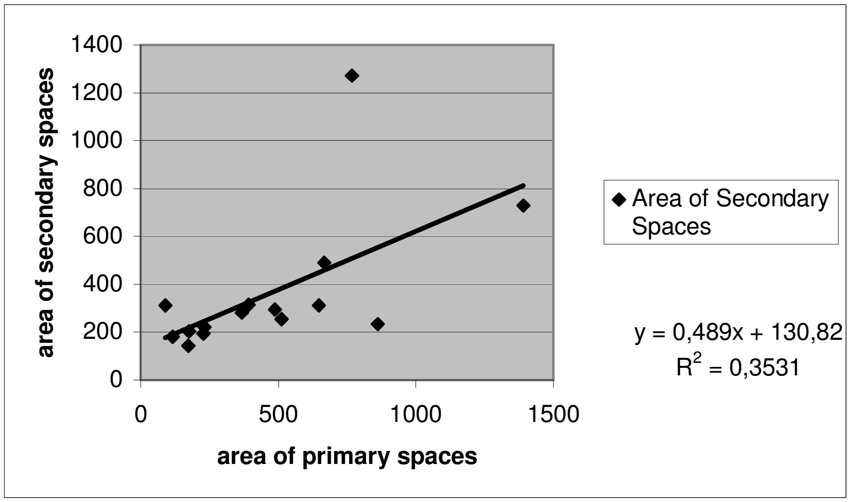

Figure 4.2 A scatter plot and least squares line for the regression of the area of secondary spaces on the area of primary spaces.

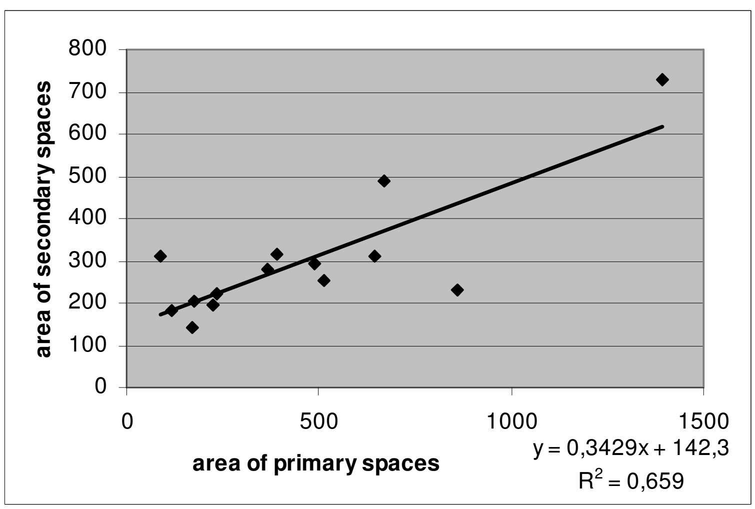

Figure 4.3 A scatter plot and least squares line for the regression of the area of secondary spaces on the area of primary spaces, without outlier.

Table 4.7 Distribution of variables, area of primary spaces and secondary spaces, without outlier.

Sample ID	Area of Primary Spaces (X)	Area of Secondary Spaces (Y)
S01	647.3	311.6
S02	860.7	232.9
S03	1391.1	729.8
S04	172.6	142.4
S05	232.4	222.1
S06	511.1	254.2
S07	226.6	194.5
S08	487.6	294.1
S09	667.0	491.1
S10	115.2	181.1
S12	366.7	280.9
S13	174.5	204.6
S14	391.8	313.5
S15	90.2	311.3

d) The regression of net usable floor area on the area of secondary spaces

While what might be considered a relatively high R^2 value–at 0.5975, and a strong positive gradient–at 1.877, was determined for the paired variables of Table 4.9, the respective scatter plot–shown in Figure 4.5–did not altogether seem to support this as, with almost 80% of the sample elements being concentrated more or less at one locality, there was little actual basis for establishing any line of least squares in the first place. In light of this particular outcome, it could therefore only be said that, apart from a few non-conforming variants which in themselves have large net usable floor areas, there was no real evidence to substantiate any dependency among the two variables considered here.

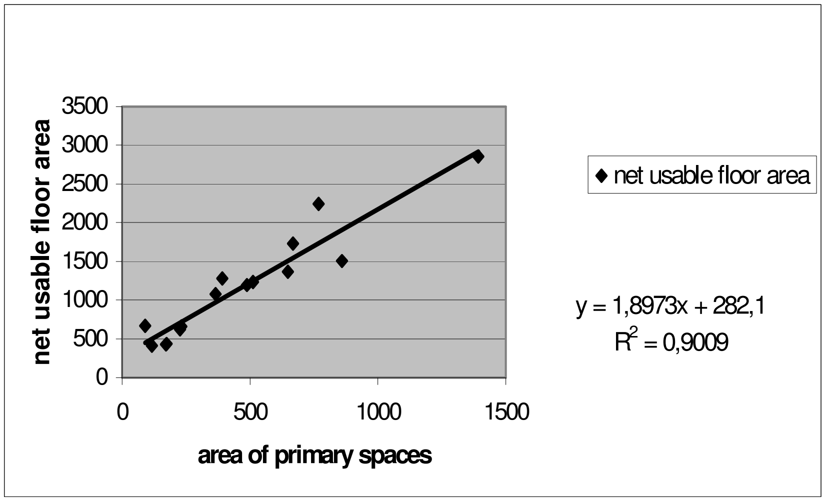

Figure 4.4 A scatter plot and least squares line for the regression of the net usable area on the area of primary spaces.

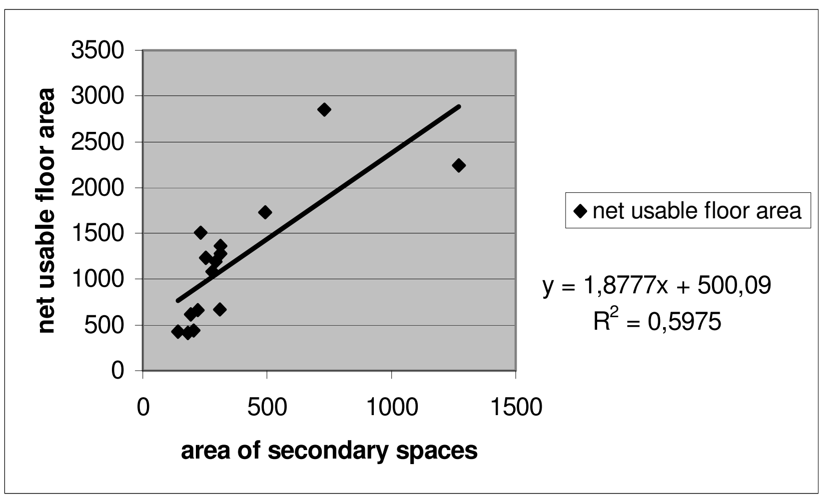

Figure 4.5 A scatter plot and least squares line for the regression of the net usable area on the area of secondary spaces.

Table 4.8 Distribution of variables, area of primary spaces and net usable floor area.

Sample ID	Area of Primary Spaces (X)	Net Usable Floor Area (Y)
S01	647.3	1363.9
S02	860.7	1508.7
S03	1391.1	2852.2
S04	172.6	424.4
S05	232.4	660.9
S06	511.1	1235.4
S07	226.6	618.5
S08	487.6	1192.0
S09	667.0	1728.1
S10	115.2	411.8
S11	767.2	2244.3
S12	366.7	1078.6
S13	174.5	437.5
S14	391.8	1280.1
S15	90.2	670.0

4.1.3 Analyses of Variance

Also considered to merit individual interpretation, the results of these analyses, as cited in section 3.2.2.c, are again presented here separately,. Thus, regarding the:-

a) Distribution of the Efficiency Quotient with Respect to Ratio 03

The null hypothesis for this distribution was that, regardless of what values were observed for ratio 03 (area of primary spaces per bed), nursing units showed no significant difference in their efficiency quotient; *i.e.* any differences there were would be of the same

Table 4.9 Distribution of variables, area of secondary spaces and net usable floor area.

Sample ID	Area of Secondary Spaces (X)	Net Usable Floor Area (Y)
S01	311.6	1363.9
S02	232.9	1508.7
S03	729.8	2852.2
S04	142.4	424.4
S05	222.1	660.9
S06	254.2	1235.4
S07	194.5	618.5
S08	294.1	1192.0
S09	491.1	1728.1
S10	181.1	411.8
S11	1270.8	2244.3
S12	280.9	1078.6
S13	204.6	437.5
S14	313.5	1280.1
S15	311.3	670.0

order in any other sample of 15 elements and could therefore be attributed to chance with a 95% level of confidance. The formal expression for this was:-

$$H_o: \tau_i = 0 \quad (\alpha = 0.05; v_1 = 2, v_2 = 12)$$

The ANOVA conducted for the distribution and the conclusion reached therefrom regarding the null hypothesis on the basis of the F-test is shown in Table 4.10, where the sum-of-squares is derived from the data summarized in Table 3.3. The conclusion that there is no significant difference among the groups in this respect is supported by their co-efficients of variation which, being quite close to one another, had already indicated a consistent variation within groups that overrode any variation shown among them. This is also reflected in the very small value of the among-groups sum-of-squares.

What this meant in practical terms was that there was no basis to relate, say, a high value for ratio 03 in any one specific nursing unit with a similarly high value in its efficiency quotient, and vice-versa. In other words, efficiency ratio showed a central tendency that was independent of the factor considered, *i.e.* area of primary spaces per bed.

Table 4.10. ANOVA for efficiency ratios, by areas of primary spaces per bed.

Source of Variation	Degrees of freedom (df)	Sum of Squares (SS)	Mean Squares (MS)	$F_{expected}$ (α=0.05; 2, 12)	$F_{calculated}$ MS_{AG}/MS_{WG}
Among Groups, (AG)	2	0.016	0.008	3.885	2.000
Within Groups, (WG)	12	0.044	0.004		
Total	14	0.060	0.004		
Conclusion : H_0 accepted with 95 % confidence.					

b) Distribution of the Efficiency Quotient with Respect to Ratio 04

Results for this distribution displayed in Table B.2 were that there was no need to continue for the analysis of variance; since, the mean for Group 3 was the same as the values of data (observations), giving a coefficient of variation of 0.00 % (zero), a variance of 0.00 (zero). The conclusion that it is not possible to distinguish the source of variation in this respect is supported co-efficients of variation.

c) Distribution of the Efficiency Quotient with Respect to Ratio 05

The null hypothesis was that, regardless of what values were observed for ratio 05 (area of circulation spaces per bed), nursing units showed no significant difference in their efficiency quotient. The formal expression for this was:-

$$H_o: \tau_i = 0 \quad (\alpha = 0.05; v_1 = 2, v_2 = 12)$$

The ANOVA conducted for the distribution and the conclusion reached therefrom regarding the null hypothesis on the basis of the F-test is shown in Table 4.11, where the sum-of-squares is derived from the data summarized in Table B.4. The conclusion that there is no significant difference among the groups in this respect is supported by their co-efficients of variation which, being quite close to one another, had already indicated a consistent variation within groups that overrode any variation shown among them.

Table 4.11 ANOVA for efficiency ratios, by areas of circulation spaces per bed.

<table>
<tr><th>Source of Variation</th><th>Degrees of freedom (df)</th><th>Sum of Squares (SS)</th><th>Mean Squares (MS)</th><th>$F_{expected}$ (α=0.05; 2, 12)</th><th>$F_{calculated}$ MS_{AG}/ MS_{WG}</th></tr>
<tr><td>Among Groups, (AG)</td><td>2</td><td>0.012</td><td>0.006</td><td rowspan="3">3.885</td><td rowspan="3">1.500</td></tr>
<tr><td>Within Groups, (WG)</td><td>12</td><td>0.048</td><td>0.004</td></tr>
<tr><td>Total</td><td>14</td><td>0.060</td><td></td></tr>
<tr><td colspan="6">Conclusion : H_0 accepted with 95 % confidence.</td></tr>
</table>

d) Distribution of the Efficiency Quotient with Respect to Ratio 11

The data and the preliminary calculations regarding this distribution, as summarized in Table B.6, having indicated nil variance, there existed no cause to carry the analysis further.

e) Distribution of the Compactness quotient with respect to the efficiency quotient

The null hypothesis was that nursing units showed no significant difference in their compactness quotient. The formal expression for this was:-

$$H_o: \tau_i = 0 \quad (\alpha = 0.05; v_1 = 2, v_2 = 12)$$

The ANOVA conducted for the distribution and the conclusion reached therefrom regarding the null hypothesis on the basis of the F-test is shown in Table 4.12, where the sum-of-squares is derived from the data summarized in Table B.8. The conclusion that there is no significant difference among the groups in this respect is supported by their co-efficients of variation which, being quite close to one another, had already indicated a consistent variation within groups that overrode any variation shown among them.

Table 4.12 ANOVA for compactness ratios, by ratio of net usable floor area to gross floor area.

Source of Variation	Degrees of freedom (df)	Sum of Squares (SS)	Mean Squares (MS)	$F_{expected}$ (α=0.05; 2, 12)	$F_{calculated}$ MS_{AG}/ MS_{WG}
Among Groups, (AG)	2	0.010	0.005	3.885	0.357
Within Groups, (WG)	12	0.167	0.014		
Total	14	0.177	0.013		
Conclusion : H_0 accepted with 95 % confidence.					

f) Distribution of Ratio 07 with respect to the Compactness quotient

The null hypothesis for this distribution was that, regardless of what values were observed for the compactness ratio (ratio of external surface area to gross floor area), nursing units showed no significant difference in their ratio of primary spaces to secondary spaces. The formal expression for this was:-

$$H_o: \tau_i = 0 \quad (\alpha = 0.05; v_1 = 2, v_2 = 12)$$

The ANOVA conducted for the distribution and the conclusion reached therefrom regarding the null hypothesis on the basis of the F-test is shown in Table 4.13, where the sum-of-squares is derived from the data summarized in Table B.10. The conclusion that there is no significant difference among the groups in this respect is supported by their co-efficients of variation.

What this meant in practical terms was that there was no basis to relate, say, a high value for the compactness ratio in any one specific nursing unit with a similarly high value in its ratio of primary spaces to secondary spaces, and vice-versa.

Table 4.13 ANOVA for ratio of primary spaces to secondary spaces, by ratio of external surface area to gross floor area.

Source of Variation	Degrees of freedom (df)	Sum of Squares (SS)	Mean Squares (MS)	$F_{expected}$ (α=0.05; 2, 12)	$F_{calculated}$ MS_{AG}/ MS_{WG}
Among Groups, (AG)	2	0.574	0.287	3.885	0.389
Within Groups, (WG)	12	8.830	0.736		
Total	14	9.404	0.672		
Conclusion : H_0 accepted with 95 % confidence.					

g) Distribution of Ratio 07 with respect to Ratio 06

The null hypothesis for this distribution was that, regardless of what values were observed for ratio 06 (constructional area per bed), nursing units showed significant difference in their ratio of primary spaces to secondary spaces. The formal expression for this was:-

$$H_o: \tau_i = 0 \quad (\alpha = 0.05; v_1 = 2, v_2 = 12)$$

Based on the data of Table B.12, the ANOVA conducted for the distribution, summarized in Table 4.14, indicated a significant difference between the two groups here. What this meant in practical terms was that high values for ratio 06 (constructional area per bed) resulted in correspondingly high values for ratio 07 (ratio of primary spaces to secondary spaces.

Table 4.14 ANOVA for ratio of primary spaces to secondary spaces, by constructional area per bed.

Source of Variation	Degrees of freedom (df)	Sum of Squares (SS)	Mean Squares (MS)	$F_{expected}$ (α=0.05; 1, 13)	$F_{calculated}$ MS_{AG}/ MS_{WG}
Among Groups, (AG)	1	2.700	2.700	4.6672	5.233
Within Groups, (WG)	13	6.704	0.516		
Total	14	9.404	0.672		
Conclusion : H_0 rejected with 95 % confidence.					

h) Distribution of Ratio 07 with respect to Ratio 11

The null hypothesis for this distribution was that, regardless of what values were observed for ratio 11 (external surface area per bed), nursing units showed no significant difference in their ratio of primary spaces to secondary spaces. The formal expression for this was:-

$$H_o: \tau_i = 0 \quad (\alpha = 0.05;\ v_1 = 2,\ v_2 = 12)$$

The ANOVA conducted for the distribution and the conclusion reached therefrom regarding the null hypothesis on the basis of the F-test is shown in Table 4.15, where the sum-of-squares is derived from the data summarized in Table B.14. The conclusion that there is no significant difference among the groups in this respect.

What this meant in practical terms was that there was no basis to relate, say, a high value for external surface area in any one specific nursing unit with a similarly high value in its ratio of primary spaces to secondary spaces, and vice-versa. In other words, ratio of primary spaces to secondary spaces showed a central tendency that was independent of the factor considered, *i.e.* external surface area per bed.

Table 4.15 ANOVA for ratio of primary spaces to secondary spaces, by external surface area per bed.

Source of Variation	Degrees of freedom (df)	Sum of Squares (SS)	Mean Squares (MS)	$F_{expected}$ (α=0.05; 2, 12)	$F_{calculated}$ MS_{AG}/MS_{WG}
Among Groups, (AG)	2	2.384	1.192	3.885	2.038
Within Groups, (WG)	12	7.020	0.585		
Total	14	9.404	0.672		
Conclusion : H_0 accepted with 95 % confidence.					

j) Distribution of Ratio 8 with respect to the Efficiency quotient

The null hypothesis for this distribution was that, regardless of what values were observed for efficiency quotient, nursing units showed no significant difference in their ratio of primary spaces to circulation spaces. The formal expression for this was:-

$$H_o: \tau_i = 0 \ (\alpha = 0.05; v_1 = 2, v_2 = 12)$$

The ANOVA conducted for the distribution and the conclusion reached therefrom regarding the null hypothesis on the basis of the F-test is shown in Table 4.16. The conclusion was that there is no significant difference among the groups in this respect. What this meant in practical terms was that there was no basis to relate, say, a high value for the ratio of primary spaces to circulation spaces in any one specific nursing unit with a similarly high value in its efficiency quotient and vice-versa.

Table 4.16 ANOVA for efficiency quotient, by primary spaces to circulation spaces.

Source of Variation	Degrees of freedom (df)	Sum of Squares (SS)	Mean Squares (MS)	$F_{expected}$ (α=0.05; 2, 12)	$F_{calculated}$ MS_{AG}/MS_{WG}
Among Groups, (AG)	2	0.154	0.077	3.885	0.127
Within Groups, (WG)	12	7.242	0.603		
Total	14	7.396	0.528		
Conclusion : H_0 accepted with 95 % confidence.					

4.2 Discussion

Despite efforts to confine the brief discourse accompanying each individual result presented in the preceeding section to interpretation of its numerical outcome, it occasionally became unavoidable that this crossed the border into the territory of its ulterior significance–territory reserved for the more formal discussion to be made here. The latent potential for repetition thus created notwithstanding, it is then hereunder that the cumulative findings of the investigation are overviewed in regard to its argument and objectives, with due reference to literature, as relevant. To avoid discursiveness, the overview first looks at specific findings from the three types of analysis implemented before going into a general evaluation. Then:-

4.2.1 Regarding Student's t-tests

In some contrast to suggestions and claims made in literature (*e.g.*, Hardy & Lammers, 1986) about the relative merits of double- versus single-corridor arrangements, the fact that sample elements showed no significant differences in this respect regarding either quotient (both efficiency and compactness) was a most noteworthy result. This was all the more so when it was duly considered that sample elements in themselves harbored broad divergences, differing as they did in dates of design and in the means by which these designs were obtained. No less, it raised a basic question about the relative veracity and aptitude of the professionals working on hospital nursing unit design, both here in Türkiye and abroad: Are units being designed here "too good to be true" in terms of consistency, irrespective of their planimetric arrangements, or is there something missing, overlooked or being done wrong? No doubt, a question for which the answer lies not here, but in further dedicated research, if it at all requires one.

In any event, it was a welcome if unexpected result that allowed the other analyses envisaged –especially of variance–to continue as originally planned; *i.e.*, without compelling data to be grouped on this basis.

4.2.2 Regarding Regression Analyses

Notable in these were several aspects: The low dependency for the area of circulation spaces on the area of primary spaces; the modest but nevertheless recognizable dependency for the area of secondary spaces on the area of primary spaces–albeit after elimination of an outlier; and the anomaly in the regression of net usable area on the area of secondary spaces. Given the lack of significance among plan types with different corridor arrangements in regard to the efficiency quotient, the high dependency found for net usable area on the area of primary spaces was considered more or less an expectable result. Taking them in turn:-

That circulation spaces showed negligible dependency on primary spaces–though by no means an indication of the opposite, *i.e.* independence–was nevertheless considered a significant finding in pointing out that, given the basis used in their distinction as described in section 3.1, extending areas allocated to patients would not necessarily incurr cost penalties–be they initial and operational–by way of adding to medically non-productive ones. Put In other words, it was viewed as an implicit invitation for greater generosity in this allocation by designers. Of course, to the point of diminishing returns.

On the other hand, the stronger dependency–*i.e.* a higher R^2 value–found with elimination of a single outlier for secondary and primary spaces was considered quite revealing as it gave support to the presumption of linearity among the two that is usually regarded to be biased insofar as it is based merely on their definitions. All the more so because this was against citings in literature (*e.g.*, Miller & Swensson, 1995) claiming that hospital designs of today were allocating less and less space to support services in light of developing technology that either rendered the equipment in question smaller and smaller, or made such spaces altogether redundant by allowing most of these to be placed directly in patient rooms. It was therefore conjectured that the time lag observed to exist in many similar cases between the advent of such developments in the world-at-large and their eventual incorporation into current design here was also in effect for the sample elements under study. However, not having anticipated such a result in this respect at the onset, no evidence to support or negate this conjecture was sought in the investigation. What can be said on the basis of existing data is that, being more or less uniformly dispersed about the regression line, there are sufficient grounds for the claim made earlier in section 4.1.2.b.

Direct implications of the anomaly observed in the regression of net usable area on the area of secondary spaces were already stated in section 4.1.2.d. More interesting was the fact that this result came about despite the fairly strong dependency between secondary and primary spaces discussed immediately above and the even stronger one between net usable area and the area of primary spaces, as reported in section 4.1.2.c. Assuming both consistency and accuracy for the original measurements and the area calculations made therefrom, the noticable lower-end concentration shown here was attributed to a concern for keeping in agreement with some normative ceiling value prescribed for the relative areas of secondary spaces–either in the design brief or in the design codes of the commissioning authority in question although, again, there being no prior anticipation of this, no corroborating evidence was sought in this direction. By the same token, the fact that the sample elements giving rise to the two discordant co-ordinates (one belonging to sample element 03, the design of which was obtained by commission, and the other to sample element 11, which was of the ministry-standardized type) showed no common distinguishing characteristics made it all the more difficult to carry the rationalization made above with any degree of conviction.

The strong dependency of net usable area on the area of primary spaces was one other result that was expected, though not to the extent found–given the expected dependency between secondary and primary spaces. Had it not been so, it would have been difficult to sustain credence for those of the ratios assigned as treatments in ANOVA using this variable.

4.2.3 Regarding Analyses of Variance

Conducted with regard to the various factor ratios cited in section 4.1.3, several of these produced quite noteworthy results. Most salient among all was that only the distribution of ratio 07 (ratio of primary spaces to secondary spaces) with respect to ratio 06 (constructional area per bed) indicated a significant difference between the two groups (treatments) in question. Just as striking was that almost all those remaining entailed acceptance of the null hypothesis, including that for the distribution of ratio 08 (ratio of primary spaces to circulation spaces) with respect to the efficiency quotient. The two exceptions were the distributions of the efficiency quotient with respect to ratio 04 (area of secondary spaces ber bed) and to ratio 11 (external surface area per bed), both of which showed negligible variance. This was indeed a most unexpected outcome.

For one, it was somewhat contrary to the regression analyses for direct area dependencies which, if nothing, indicated a certain degree of linearity between at least some of the components making up the ratios in question. Apparently, the use of bed count as the denominator for the factor ratios played a considerable part in this outcome. In other words, the reduction to a per-bed basis created such a blanketing uniformity that there remained practically no opportunity for the efficiency quotient to show any divergence form the norm.

Two: given the numerical values obtained for the quotient from the sample elements, it was only natural to originally assume that these would necessarily vary simply due to the large variation observed for both the numerator and denominator of the factor ratios being used as a matter of course; hence, the inclusion of this analysis in the investigation programme.

Finally, for those analyses where F-tests resulted in acceptance of their respective null hypotheses, it can only be said that insofar as the factor and variant ratios used were considered to be teneable if not relevant ones, there was a basic and commendable achievement of design uniformity that nullified any group effects, irrespective of the variation in both design origin and date.

4.2.4 Regarding the Investigation Overall

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. It was, therefore, possible to compare this study with those mentioned above although they are distinct in their contents and techniques; however, only one study which was conducted by Hardy & Lammers(1986) dealed with design efficiency of hospitals by using ratios of floor areas as indicators; although that showed various differences in objectives and method.

Subjects of operational researches stated by Bailey(1956) and Kliment(2000) were the internal traffic patterns which were analysed by such indicators, walking distances and walking routes to improve nursing efficiency in nursing units. In this study, however, ratios of nursing unit floor areas were indicators to analyze design efficiency of nursing units. Such similarities of their aims are significant;that is, obtaining lowest possible in-use operational and maintenance costs, providing best possible patient care in terms of medical servives, 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 (1969,92), Aydın (2004), Gainsborough and Gainsborough (1964), Agron(1978). Kliment (2000), Catananti,Damiani, and Capelli (1998), Bailey (1956).

Although this study was carried out with 15 samples-hospitals-, it was demonstrated that five out of eigth variables mentioned in Method did not have significant role in satisfying design efficiency in nursing units of hospitals; however, results showed that for two of them it was not possible to distinguish the source of variation by two factors; so it was not possible to continue with analyses. By constructional area per bed, results for ratio of primary spaces to secondary spaces showed significant differences. Further studies may be carried out in order to investigate the causes of these significant differences among constructional area per bed.

Results, as told, indicated that although hospitals with various types of nursing unit floor plans; ones with different design origins; and ones located in different provinces were analyzed, no significant difference among those according to the various analog indicators mentioned in Material were observed. This lead to a conclusion that not only there has been no development or change in healthcare design criteria for those located in the research area, but also there has been no related researches about design efficiency of hospitals.

Further studies may also be carried out with a larger number of samples including more types of hospitals, and these may be analysed according to more certain variables than ones used in this study. This method applied on these samples also may be used for other departments of a hospital or for other building types.

CHAPTER 5

CONCLUSIONS

To establish a tenable foundation, conclusions to be derived from the study were viewed from two distinct but interrelated standpoints: Those regarding the investigation as one dealing with the broader issue of planimetric design efficiency, *i.e.* methodology; and those regarding the investigation as one dealing with that of nursing units in healthcare facilities, *per se*; *i.e.* subject-matter. The two are presented under their respective headings as follow.

5.1 Conclusions On Methodology

The case for the need of efficient layouts in healthcare facilities–and especially in their nursing units–being already as stated in the argument, the main question here was one of defining not just the analog indicators that could justifiably be used as determinants of this, but also the factors and/or criteria by means of which that of any given layout could be compared with that of another, there hardly being one specific norm against which such comparisons could be made. The problem became even more acute as, being mostly of a parochial nature, *i.e.* essentially relevant to the country for which they were originally developed and therefore not necessarily of universal validity, those norms that did happen exist could not be taken at face value for the study on hand, which was itself confined to such of these facilities in Türkiye that were within the public domain.

Much time and effort was thus spent on constructing a non-normative framework for the investigation so undertaken; a framework that could at best be called an intra-mural one and, as such, one based on values actually attained rather than on those to a lesser or greater extent perfunctorily prescribed and, perhaps, therefore all the more unattainable. In this, dire need was felt for quantitative data directly available from the study material, similar to that required by approval authorities for heating-load calculations ever since the energy crisis of the early 1970s; surely design efficiency issues are to be considered in the same order of importance as the conservation of heating enery. Specifically, needed was pre-calculated data on the various area allocations that would be pertinent to any planimetric efficiency evaluation, regardless of its particular method. Lack of such was indeed an overwhelming drawback, as all area calculations had to be individually and meticulously done by the author without loss of consistency; a task that called for many re-starts–due not only to the time span involved in going through a given sample element, but also to the often incomplete dimensioning and space designations on the production drawings made available.

To be in keeping with literature, the main variable was taken as the ratio of net-to-gross floor area–here, called the "efficiency quotient". The variation of this was then analyzed in terms of certain other ratios that were considered relevant factors according to the precepts defined by the author. Be this as it may, there remained some uncertainity as to whether or not these were indeed germane ones for the purposes of the study. A further aspect in this vein was the determination of group intervals for the factor ratios: The outlook being to obtain, as far as possible, equal group sizes, some adjustments in these, albeit at decimal fraction level, did become unavoidable. Where the overall range of the factor ratios allowed, effort was made to form at least three groups and only where this was rationally untenable did it become necessary to accept having two.

On the other hand–and to the extent that the ratios used could in themselve be considered tenable ones–it was a foregone conclusion that, alternatively, the efficiency quotient itself could equally well have been used as the base factor against which the variation of all the other ratios were analyzed. Though beyond the scope defined for this study, a comparison between the results of such an approach and those determined from the one at hand would certainly have been interesting. One analyses using this as the factor ratio was nevertheless carried out for the variation the compactness quotient–not for the purpose just noted, but as an indirect measure for potential thermal performance, since this too was considered a design efficiency issue. Another such analsis was the one for ratio 08 (the ratio of primary spaces to circulation spaces) in consideration of the fact that a similar ratio is often a stipulation in design briefs, be they for competitions or commissions. That no significant difference was found among the sample elements when grouped according to the factor in question was in itself found to be noteworthy in that it was indicative of a marked central tendency to remain within a narrow range; a commendable achievement on the part of their designers, though perhaps not one particularly striven for.

The various questions noted above–and any others that may be raised by critical observers–notwithstanding, it was considered that, overall, the method formulated here was, to all intents and purposes, both a viable and an appropiate one; not just for the subject population, but one that, with germane modifications, could equally well be applied to the planimetric design efficiency assessment of healthcare facilities as a whole, if not to that of buildings embodying totally different functions. In this, added to the indicators developed here could certainly be those based on direct in-use observation, such as frequency and duration of staff trips to and from various spaces, as well as those based on hospital records, such as patient turnover rates, including duration of treatments and ratios of room occupancy.

5.2 Conclusions On Subject-Matter

This investigation dealt with the planimetric design efficiency achieved in the nursing units of purpose-designed public healthcare facilities in Türkiye. In this, it concentrated on certain ratios deemed to be relevant analog (indirect) indicators of such and thence establishing, if existent, salient factors to which observed variations in these could be ascribed, with the ulterior purpose of providing apt feedback for future designers in this regard. The ratios considered were derived on the basis of areas calculated from the production drawings of sample elements. The drawings themselves were obtained from the archives of the various authorities under which the facilities operated.

Of primary concern was how the efficiency quotient (ratio of net-to-gross floor area) varied according to a series of other area allocation ratios and whether or not this showed any statistically significant difference in terms of their magnitudes. In other words, to see if there was any factor ratio that acted as a determinant of such variation. The outcomes of these investigations were presented and briefly discussed in Chapter 4. In these, the fact that the efficiency ratio showed no significant difference with respect to the factor ratios in question –regardless of any pre-conceptions to the contrary–was certainly the most noteworthy. While perhaps not in the same order of importance, also of note was the significant difference seen to exist among the area ratios of primary spaces to secondary spaces (ratio 07) when grouped with respect to the magnitudes of ratio 06 (constructional area per bed). As ratio 06 was considered a latent indicator for the degree of moderation–or extravagance–practiced in creation of the builsing domain and, hence, the cost of unusable space to the patient, the fact that high values for this ratio gave low values for ratio 07 was necessarily interpreded as a negative aspect, since it implied an over-compartmentation, if not an over-elaboration, in the serving spaces to the detriment of the served spaces; *i.e.* spaces allocated to patient use.

The inertness, so to speak, of the efficiency quotients in responding to the factor ratios was even more striking when the fact that they were all derived from planimetric layouts showing a remarkably broad diversity of form was taken into consideration. Not only this, but also the fact that the layouts themselves pertained to different times and were obtained through quite different procedures–where some were by commission, some by competition and others yet by direct use of a standardized typology–was what rendered such an outcome all the more remarkable. In light of these findings, it could only be concluded that, though the magnitudes of the efficiency quotients themselves were not questioned–nor compared with any antecedent norm, there was indeed a healthy consistency to them quite independent of what all other indicators of area allocation/utilization happened to be in magnitude; key indicators such as area of primary spaces per bed; area of secondary spaces per bed; and area of circulation spaces per bed.

Analyses regarding the variation of the compactness quotient yielded similar results: no significant differences could be established with respect to the efficiency quotient nor with respect to the ratio of primary spaces to secondary spaces. In other words, there was a general and consistent compactness quotient that was–knowingly or not–being maintained regardless of other potentially pertinent factors and that this was, again, despite the broad variation in planimetric layout shown by the sample elements.

While, all told, it cannot be said that the two principal quotients under study in themselves indicated particularly efficient planimetric designs for the population in question, there was clear evidence that a latent effort was being shown by designers to uphold the basic tenets of functional healthcare architecture without concession to any transient currents. The qualifier, 'latent', has been used here merely owing to the fact that had it been overt, there would have been explicit indications of this outlook on the study material (the drawings)–if not as specific and detailed calculations of certain pertinent ratios similar to the ones used here, at least as an overall efficiency quotient.

What does remain is the conveyance of these findings to the various bodies charged with overseeing healthcare facility design, with a mild reminder that, although for the most part of a laudable consistency insofar as the the variation in the efficiency quotients is concerned, it behooves them to establish viable and attainable norms–based on perhaps more extensive investigations of this ilk; not only for the quotient itself , but also for its sub-components–the various factor ratios used herein. Most preferable, of course, would be that such further research 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.

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APPENDIX A

SAMPLE DATA SHEET

Table A.1 Data sheet for general information about selected samples

Hospital ID:__________________ Block ID:__BLOCK A_____ Floor ID:_3____						
Gross Floor Area:_3353.9_ Outer wall perimeter:_397.5m_ Exterior wall area:_1192.5m^2 Number of Beds :_118_						
	Space ID & description	Width (w) m	Length (l) m	Height (h) m	Net usable area m^2	Total net usable area m^2
1	2-bed ward	3.625	4.950	3.05	17.944	
		1.700	2.400		4.080	
		0.300	0.900		0.270	
		0.150	1.100		0.165	22.459
2	WC-shower	0.900	2.250	3.00	2.025	
		0.400	0.900		0.360	2.385
3	2-bed ward	3.625	4.950	3.05	17.944	
		1.700	2.400		4.080	
		0.300	0.900		0.270	
		0.150	1.100		0.165	22.459
4	WC-shower	0.900	2.250	3.00	2.025	
		0.400	0.900		0.360	2.385
5	2-bed ward	3.625	4.950	3.05	17.944	
		1.700	2.400		4.080	
		0.300	0.900		0.270	
		0.150	1.100		0.165	22.459
6						

APPENDIX B

DATA GROUPED FOR ANOVA

Table B.1 Areas of secondary spaces per bed (ratio 04), ranked in ascending order, with their corresponding efficiency quotients.

Sample ID	Ratio 04	Efficiency quotient
S02	3.1	0.8
S06	5.1	0.9
S04	5.7	0.8
S08	5.9	0.9
S05	6.0	0.9
S03	6.2	0.8
S01	6.5	0.8
S07	6.9	0.8
S13	8.2	0.7
S09	9.8	0.8
S14	10.5	0.7
S12	11.2	0.7
S11	13.2	0.8
S10	18.1	0.8
S15	31.1	0.8

Table B.2 Distribution of efficiency quotients with respect to ratio 04.

	Group 1 2.5-9.5	Group 2 9.6-16.6	Group 3 16.7-30.8	ΣX_i
	0.8	0.8	0.8	2.4
	0.9	0.7	0.8	2.4
	0.8	0.7		1.5
	0.9	0.8		1.7
	0.9			0.9
	0.8			0.8
	0.8			0.8
	0.8			0.8
	0.7			0.7
ΣX_j	7.4	3.0	1.6	12.0
n	9	4	2	15
X (mean)	0.82	0.75	0.80	0.80
s_x (standard error)	0.020	0.029	0.00	
s^2 (variance)	0.004	0.003	0.00	
V (coefficient of variation)	7.36 %	7.68 %	0.00 %	

Table B.3 Areas of circulation spaces per bed (ratio 05), ranked in ascending order, with their corresponding efficiency quotients.

Sample ID	Ratio 05	Efficiency quotient
S13	2.3	0.7
S04	4.4	0.8
S02	5.5	0.8
S05	5.6	0.9
S03	6.2	0.8
S01	8.4	0.8
S07	7.1	0.8
S08	8.2	0.9
S06	9.4	0.9
S09	11.4	0.8
S10	11.5	0.8
S11	11.7	0.8
S12	17.2	0.7
S14	26.7	0.7
S15	26.9	0.8

Table B.4 Distribution of efficiency quotients with respect to ratio 05.

	Group 1 1.9-9.9	Group 2 10.0-18.0	Group 3 18.1-27.1	ΣX_i
	0.7	0.8	0.7	2.2
	0.8	0.8	0.8	2.4
	0.8	0.8		1.6
	0.9	0.7		1.6
	0.8			0.8
	0.8			0.8
	0.8			0.8
	0.9			0.9
	0.9			0.9
ΣX_j	7.4	3.1	1.5	12.0
n	9	4	2	15
X (mean)	0.82	0.78	0.75	0.80
s_x (standard error)	0.022	0.025	0.050	
s^2 (variance)	0.005	0.003	0.005	
V (coefficient of variation)	8.13 %	6.45 %	9.43 %	

Table B.5 External surface area per bed (ratio 11), ranked in ascending order, with their corresponding efficiency quotients.

Sample ID	Ratio 11	Efficiency quotient
S03	10.1	0.8
S08	11.0	0.9
S11	11.3	0.8
S05	11.5	0.9
S07	11.6	0.8
S13	12.9	0.7
S04	13.0	0.8
S02	13.2	0.8
S06	13.8	0.9
S01	15.1	0.8
S14	18.5	0.7
S12	23.0	0.7
S09	25.5	0.8
S10	28.9	0.8
S15	36.3	0.8

Table B.6 Distribution of efficiency quotients with respect to ratio 11.

	Group 1 10.0-18.0	Group 2 18.1-26.1	Group 3 26.2-34.2	ΣX_i
	0.8	0.7	0.8	2.3
	0.9	0.7	0.8	2.4
	0.8	0.8		1.6
	0.9			0.9
	0.8			0.8
	0.7			0.7
	0.8			0.8
	0.8			0.8
	0.9			0.9
	0.8			0.8
ΣX_j	8.2	2.2	1.6	12.0
n	10	3	2	15
X (mean)	0.82	0.73	0.8	0.8
s_x (standard error)	0.020	0.033	0.00	
s^2 (variance)	0.004	0.004	0.00	
V (coefficient of variation)	7.71 %	7.93 %	0.00 %	

Table B.7 Net usable floor area to gross floor area (efficiency ratio), ranked in ascending order, with their corresponding compactness quotients.

Sample ID	Efficiency quotient	Compactness quotient
S12	0.7	0.4
S13	0.7	0.6
S14	0.7	0.3
S01	0.8	0.4
S02	0.8	0.5
S03	0.8	0.4
S04	0.8	0.5
S07	0.8	0.4
S09	0.8	0.6
S10	0.8	0.5
S11	0.8	0.2
S15	0.8	0.4
S05	0.9	0.6
S06	0.9	0.5
S08	0.9	0.4

Table B.8 Distribution of compactness quotients with respect to the efficiency quotient.

	Group 1 0.7	Group 2 0.8	Group 3 0.9	ΣX_i
	0.4	0.4	0.6	1.4
	0.6	0.5	0.5	1.6
	0.3	0.4	0.4	1.1
		0.5		0.5
		0.4		0.4
		0.6		0.6
		0.5		0.5
		0.2		0.2
		0.4		0.4
ΣX_j	1.3	3.9	1.5	6.7
n	3	9	3	15
X (mean)	0.43	0.43	0.50	0.45
s_x (standard error)	0.088	0.037	0.058	
s^2 (variance)	0.024	0.013	0.010	
V (coefficient of variation)	35.53 %	26.00 %	20.00 %	

Table B.9 External surface area to gross floor area (compactness quotient), ranked in ascending order, with their corresponding primary spaces to secondary spaces (ratio 07).

Sample ID	Compactness quotient	Ratio 07
S11	0.2	0.6
S14	0.3	1.3
S01	0.4	2.1
S03	0.4	1.9
S07	0.4	1.2
S08	0.4	1.7
S12	0.4	1.3
S15	0.4	0.3
S02	0.5	3.7
S06	0.5	2.0
S10	0.5	0.6
S04	0.6	1.2
S05	0.6	1.1
S09	0.6	1.4
S13	0.6	0.9

Table B.10 Distribution of ratio 07 with respect to the compactness quotients.

	Group 1 0.15-0.30	Group 2 0.31-0.46	Group 3 0.47-0.62	ΣX_i
	0.6	2.1	3.7	6.4
	1.3	1.9	2.0	5.2
		1.2	0.6	1.8
		1.7	1.2	2.9
		1.3	1.1	2.4
		0.3	1.4	1.7
			0.9	0.9
ΣX_j	1.9	8.5	10.9	21.3
n	2	6	7	15
X (mean)	0.95	1.42	1.56	1.42
s_x (standard error)	0.351	0.264	0.393	
s^2 (variance)	0.495	0.418	1.083	
V (coefficient of variation)	52.10 %	45.51 %	66.70 %	

Table B.11 Constructional area per bed (ratio 06), ranked in ascending order, with their corresponding primary spaces to secondary spaces (ratio 07).

Sample ID	Ratio 06	Ratio 07
S05	2.1	1.1
S06	2.2	2.0
S08	3.1	1.7
S07	3.7	1.2
S04	3.9	1.2
S02	4.1	3.7
S03	4.2	1.9
S13	6.0	0.9
S09	6.3	1.4
S01	7.8	2.1
S10	12.7	0.6
S12	13.8	1.3
S15	15.6	0.3
S14	16.2	1.3
S11	31.2	0.6

Table B.12 Distribution of ratio 07 with respect to ratio 06.

	Group 1 2.0-11.7	Group 2 11.8-21.5	ΣX_i
	1.1	0.6	1.7
	2.0	1.3	3.3
	1.7	0.3	2.0
	1.2	1.3	2.5
	1.2	0.6	1.8
	3.7		3.7
	1.9		1.9
	0.9		0.9
	1.4		1.4
	2.1		2.1
ΣX_j	17.2	4.1	21.3
n	10	5	15
X (mean)	1.720	0.820	1.42
s_x (standard error)	0.256	0.203	
s^2 (variance)	0.653	0.207	
V (coefficient of variation)	46.98 %	55.49 %	

Table B.13 External surface area per bed (ratio 11), ranked in ascending order, with their corresponding primary spaces to secondary spaces (ratio 07).

Sample ID	Ratio 11	Ratio 07
S03	10.1	1.9
S08	11.0	1.7
S11	11.3	0.6
S05	11.5	1.1
S07	11.6	1.2
S13	12.9	0.9
S04	13.0	1.2
S02	13.2	3.7
S06	13.8	2.0
S01	15.1	2.1
S14	18.5	1.3
S12	23.0	1.3
S09	25.5	1.4
S10	28.9	0.6
S15	36.3	0.3

Table B.14 Distribution of ratio 07 with respect to ratio 11.

	Group 1 10.0-18.0	Group 2 18.1-26.1	Group 3 26.2-34.2	ΣX_i
	1.9	1.3	0.6	3.8
	1.7	1.3	0.3	3.3
	0.6	1.4		2.0
	1.1			1.1
	1.2			1.2
	0.9			0.9
	1.2			1.2
	3.7			3.7
	2.0			2.0
	2.1			2.1
ΣX_j	16.4	4.0	0.9	21.3
n	10	3	2	15
X (mean)	1.64	1.33	0.45	1.42
s_x (standard error)	0.278	0.033	0.150	
s^2 (variance)	0.774	0.004	0.045	
V (coefficient of variation)	53.63 %	4.35 %	47.13 %	

APPENDIX C

SCHEMATIC DRAWINGS OF SAMPLES

In this section are presented schematic drawings of samples—nursing unit floor—. A legend was prepared in order to present three basic spaces namely primary spaces, secondary spaces, and circulation spaces. While darker areas are representing circulation spaces, lighter areas are secondary spaces; the rest are for primary spaces.

Space designations, dimensions, and any furnishing were excluded on these drawings since, the aim was to indicate areas of pre-described spaces, as designated functional classification of spaces in Material.

Figure C.1 Schematic plan of Sample 01 displaying primary, secondary and circulation spaces.

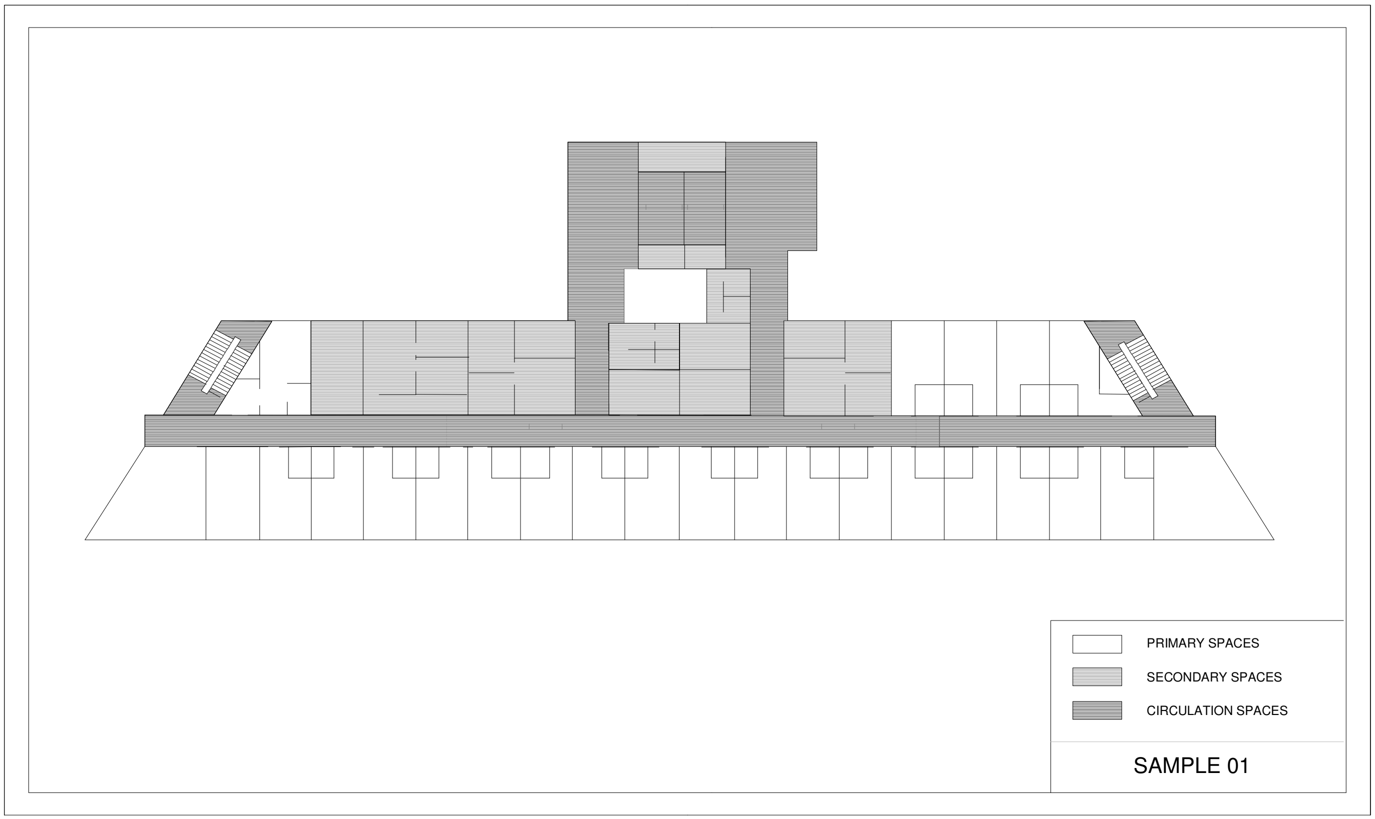


Figure C.2 Schematic plan of Sample 02 displaying primary, secondary and circulation spaces.

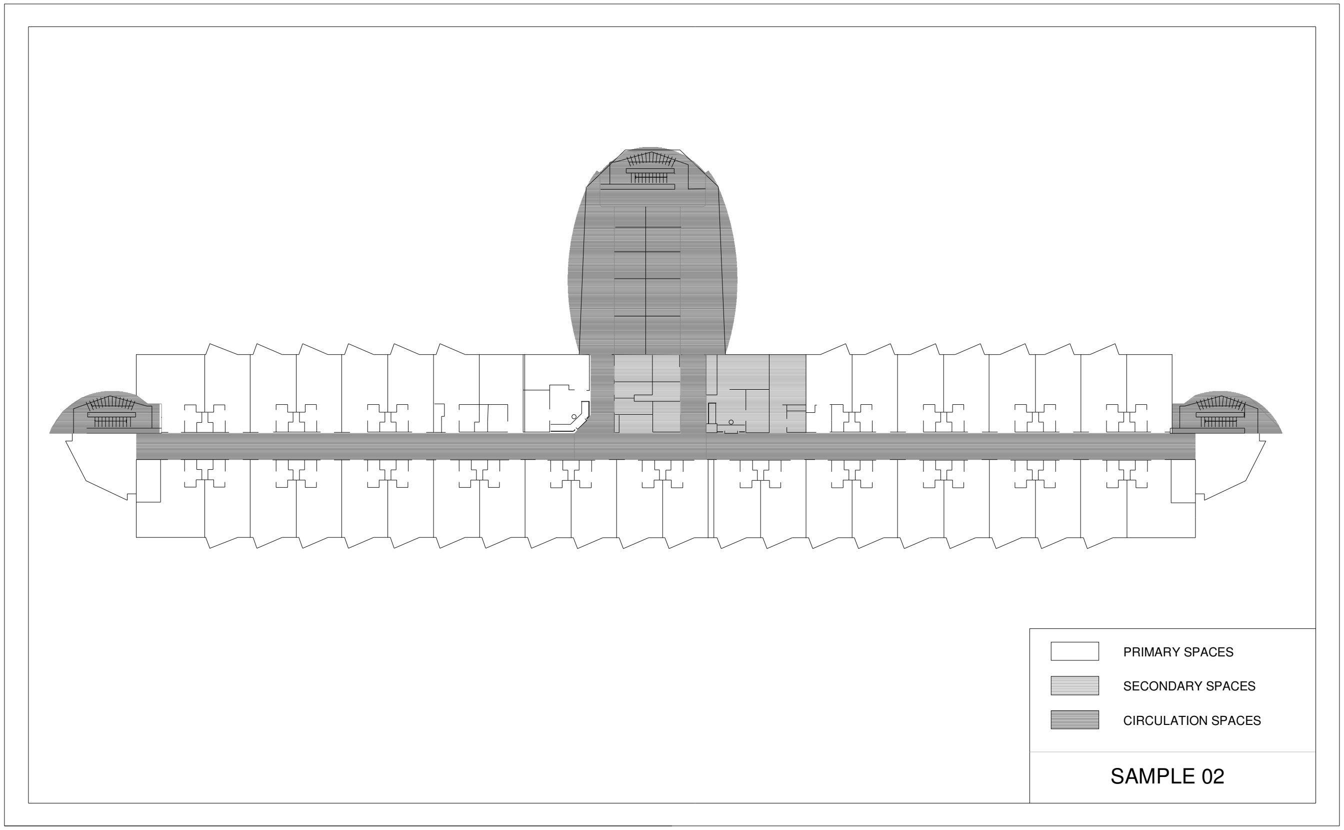


Figure C.3 Schematic plan of Sample 03 displaying primary, secondary and circulation spaces.

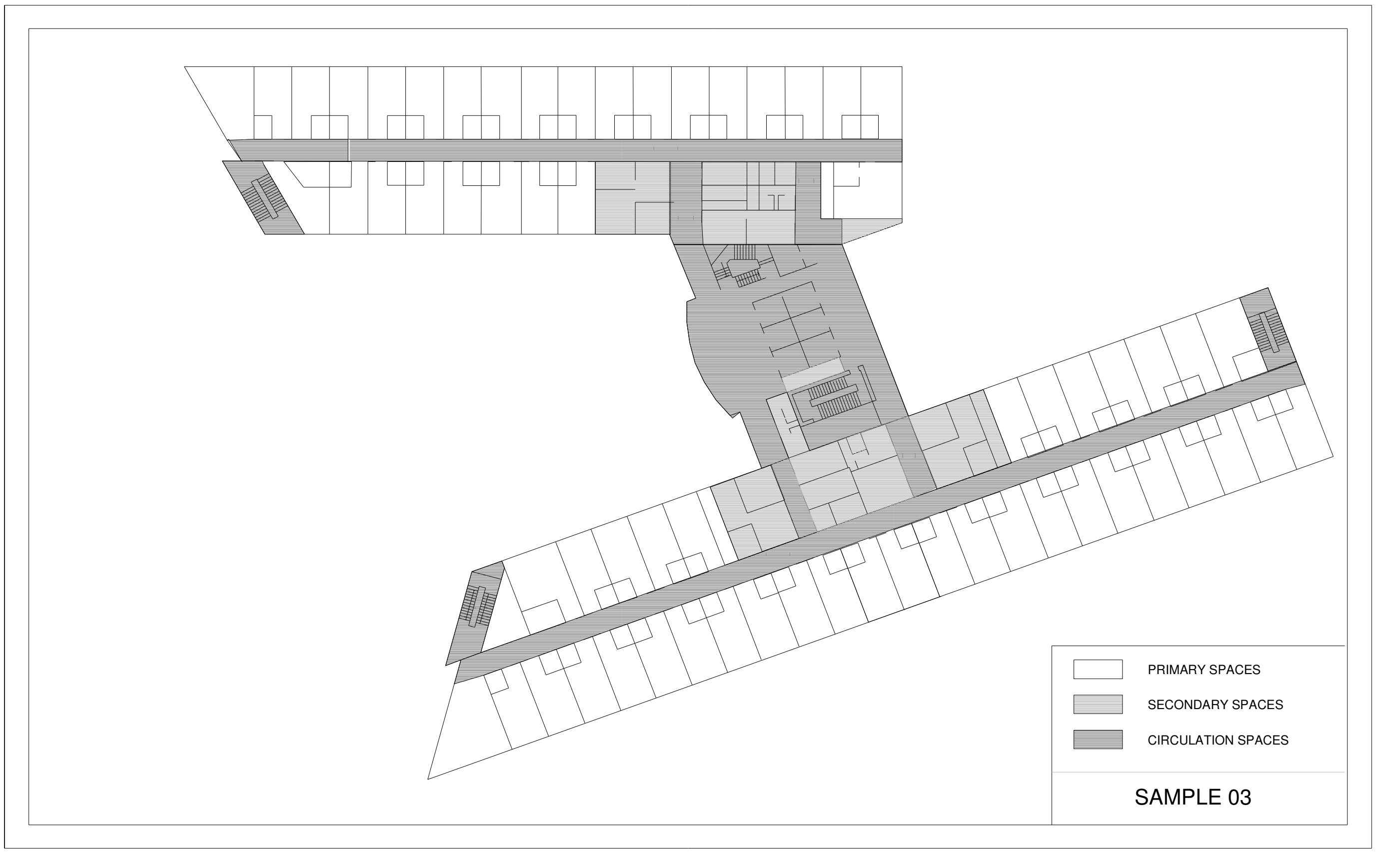


Figure C.4 Schematic plan of Sample 04 displaying primary, secondary and circulation spaces.

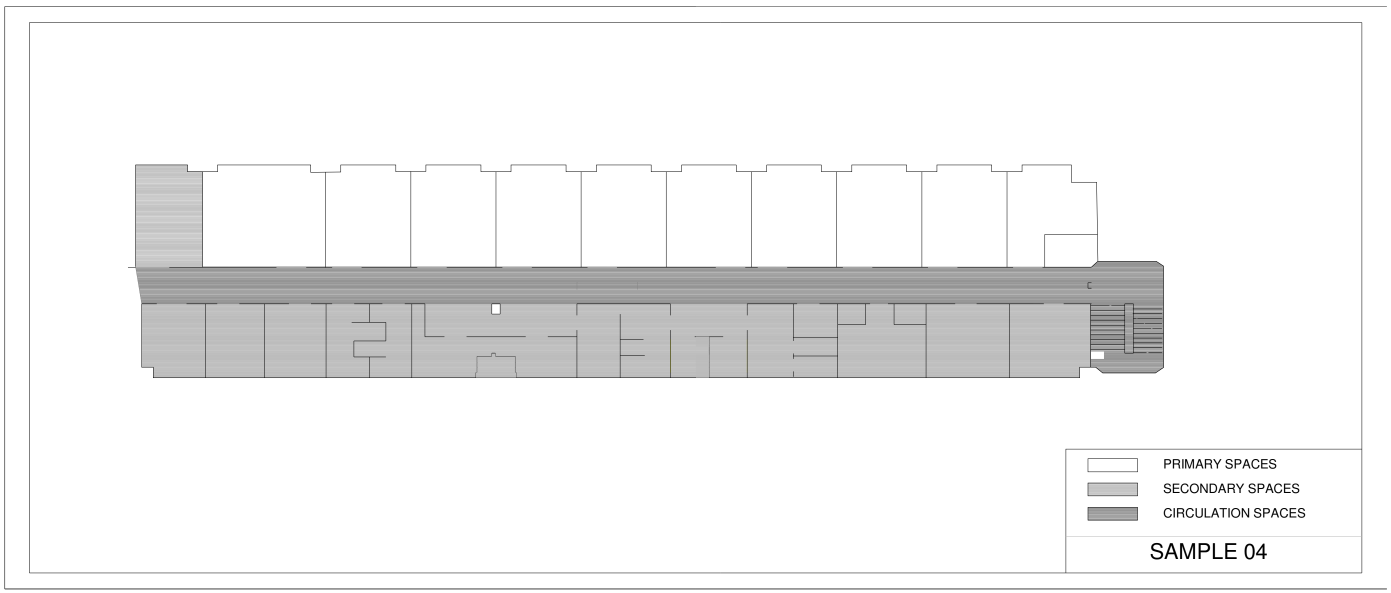


Figure C.5 Schematic plan of Sample 05 displaying primary, secondary and circulation spaces.

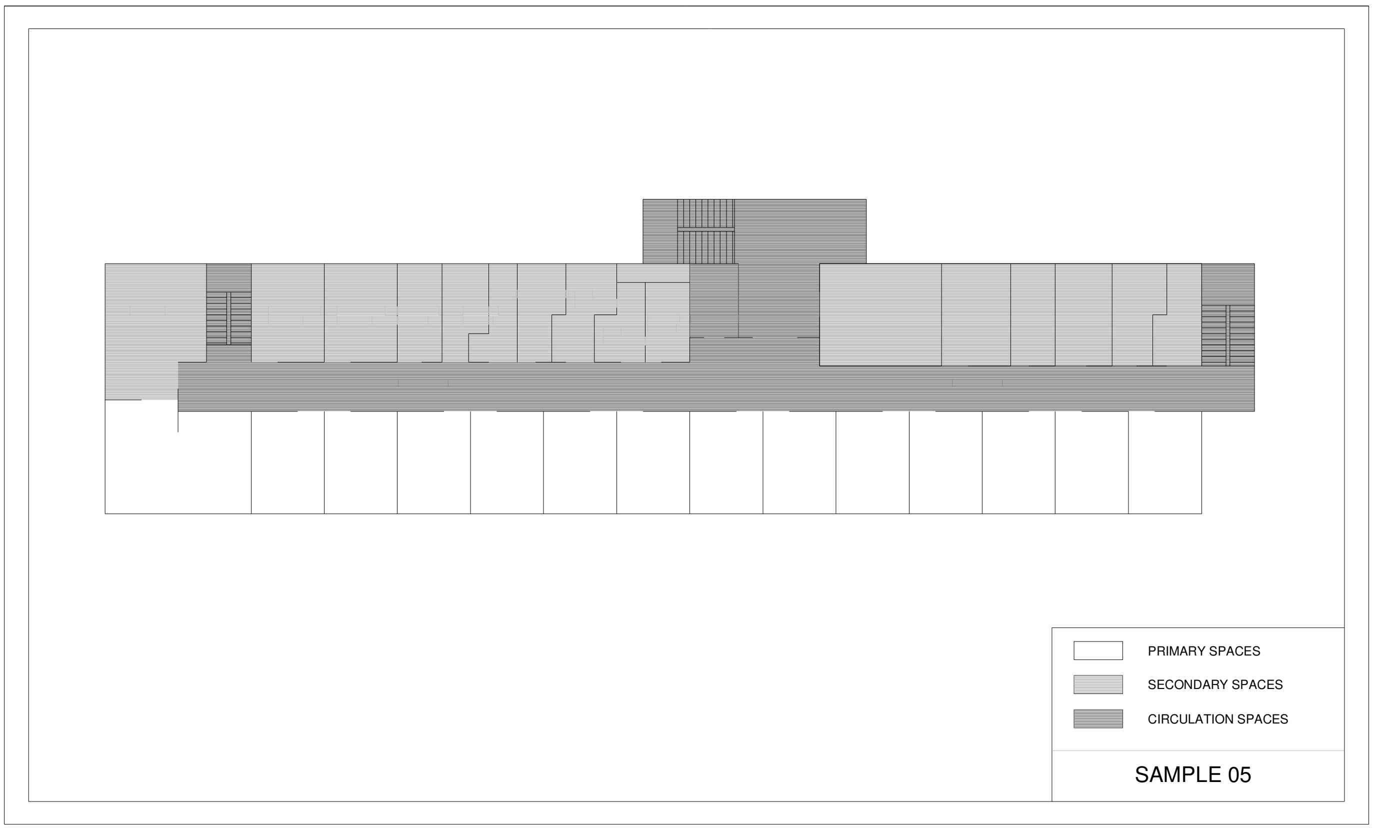


Figure C.6 Schematic plan of Sample 06 displaying primary, secondary and circulation spaces.

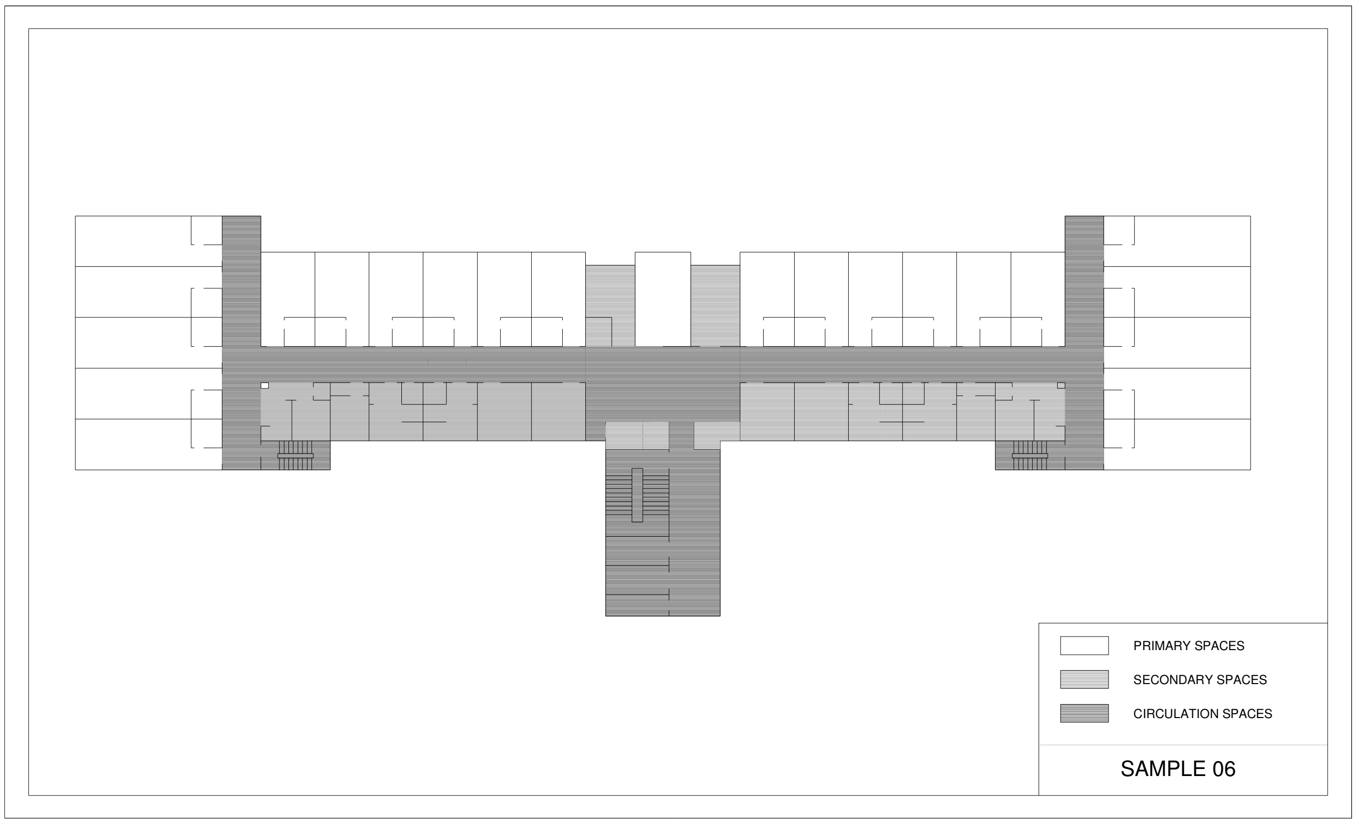


Figure C.7 Schematic plan of Sample 07 displaying primary, secondary and circulation spaces.

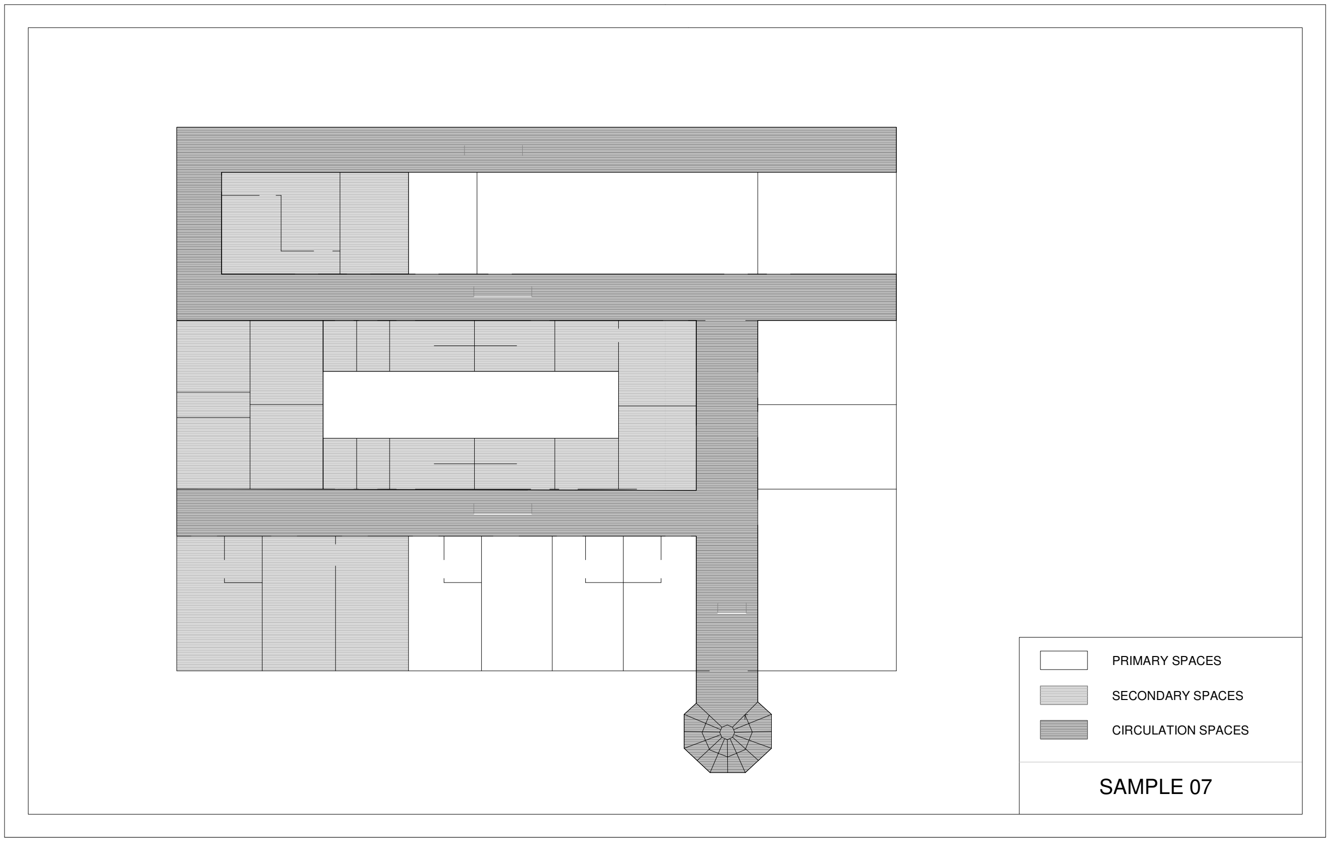


Figure C.8 Schematic plan of Sample 08 displaying primary, secondary and circulation spaces.

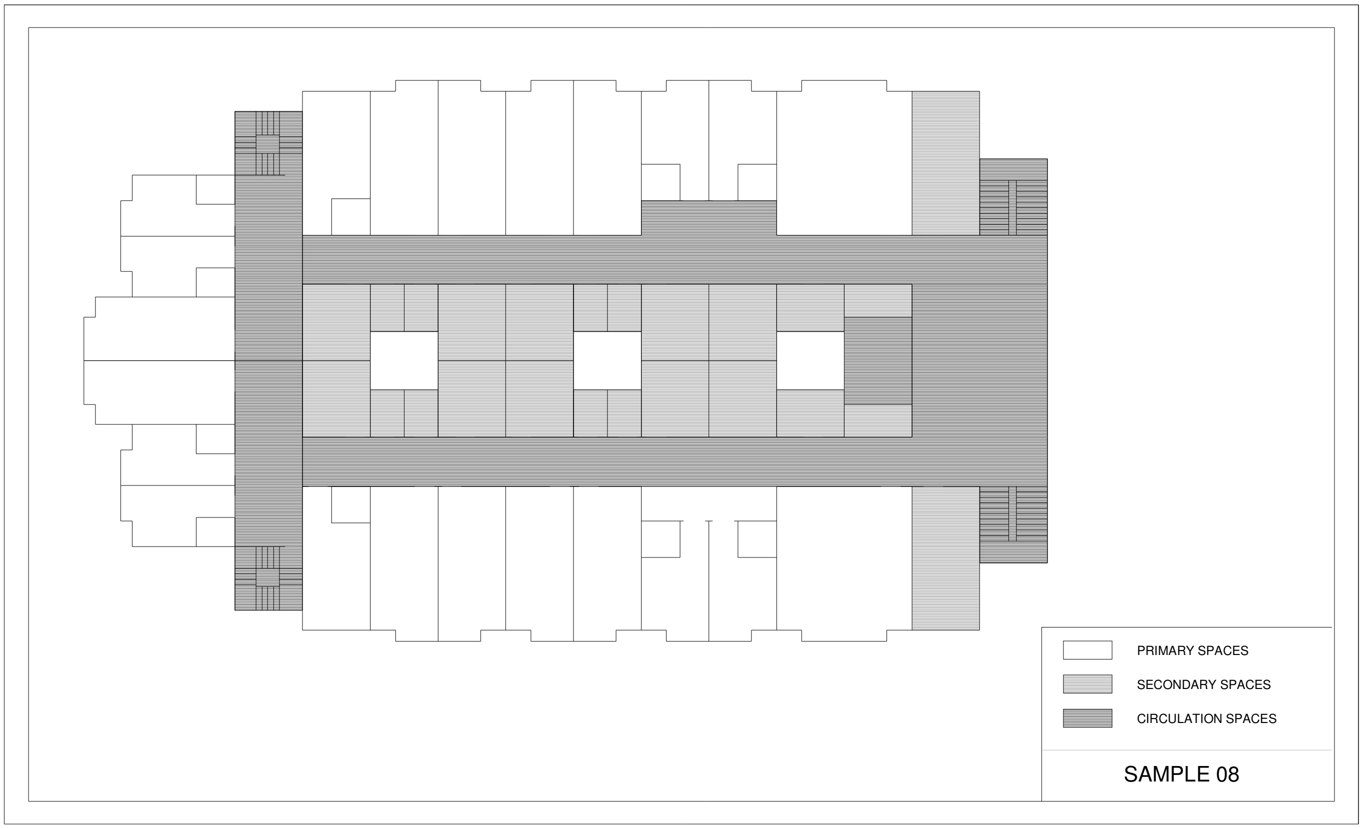


Figure C.9 Schematic plan of Sample 09 displaying primary, secondary and circulation spaces.

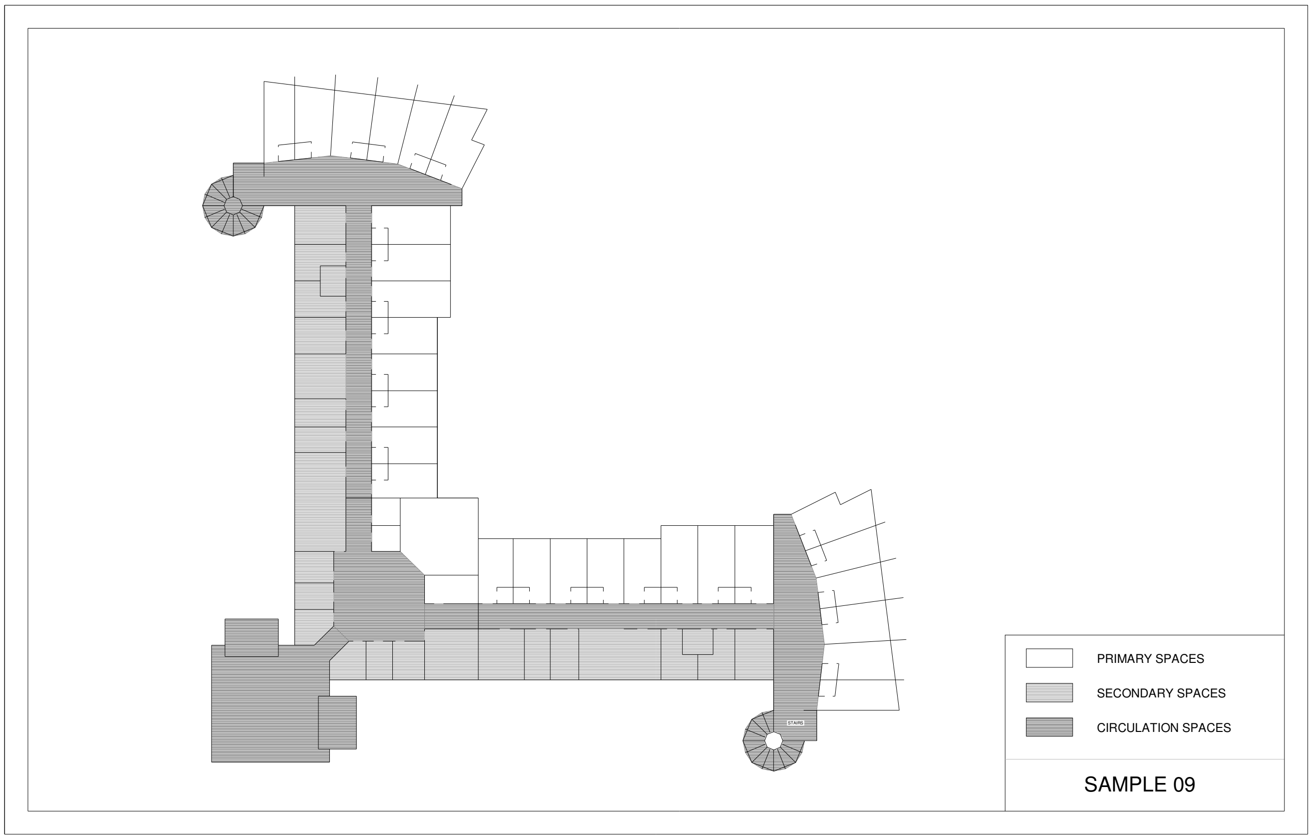


Figure C.10 Schematic plan of Sample 10 displaying primary, secondary and circulation spaces.

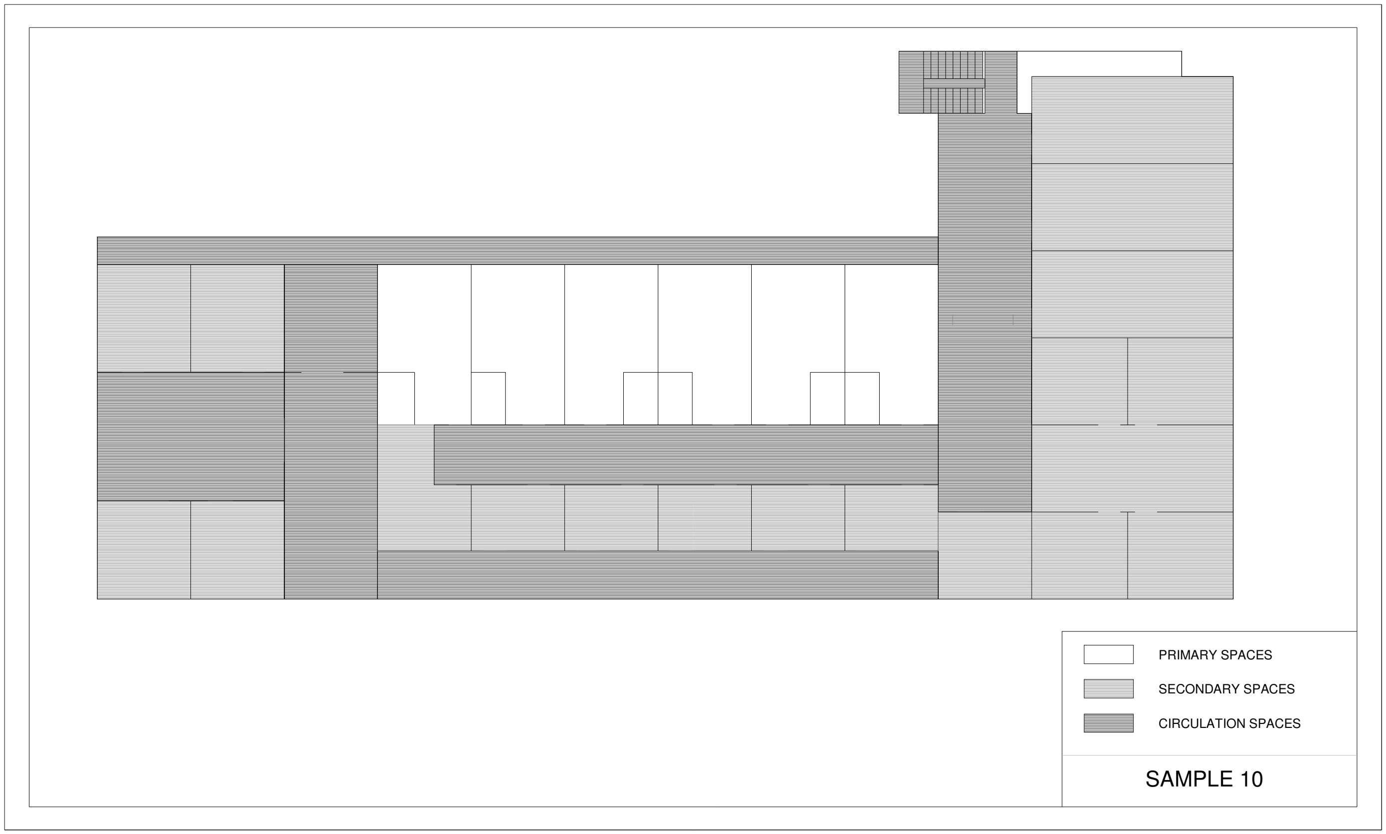


Figure C.11 Schematic plan of Sample 11 displaying primary, secondary and circulation spaces.

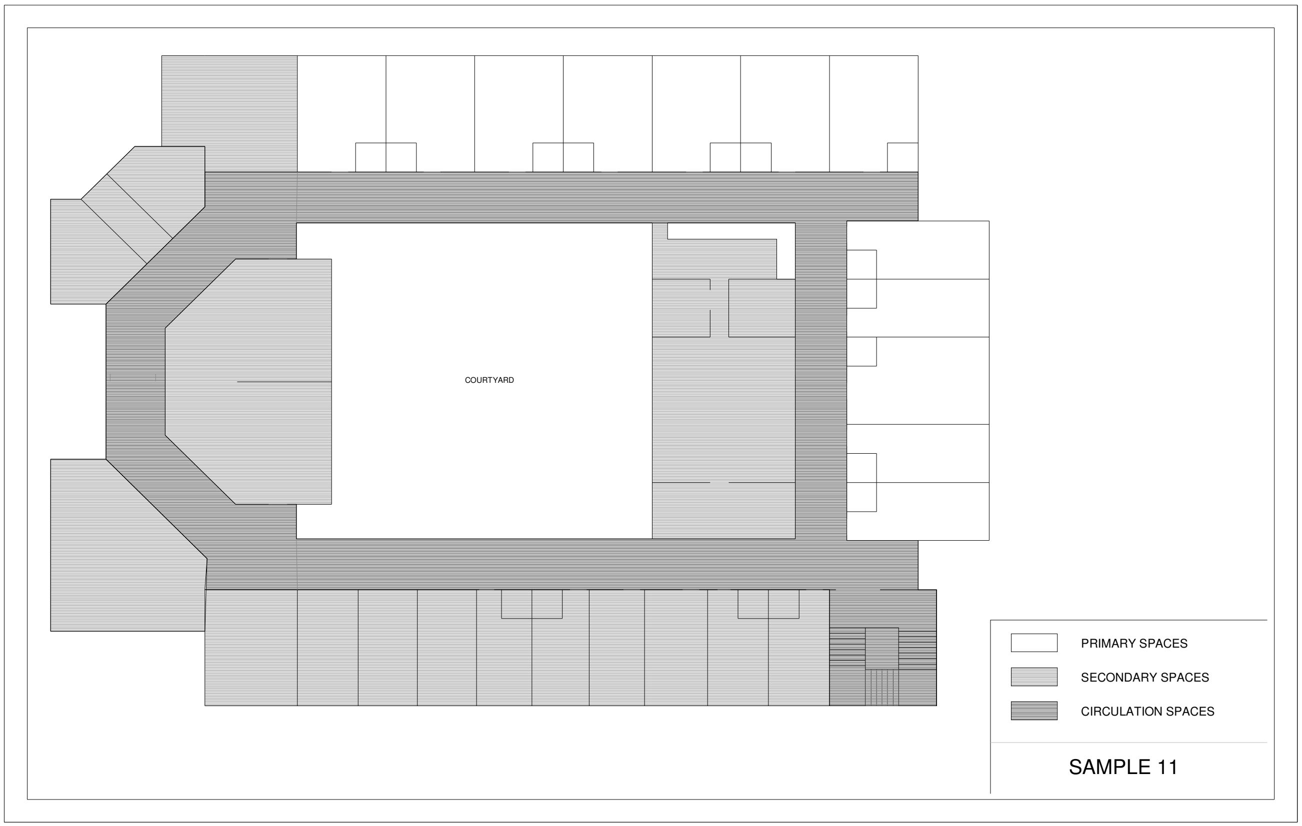


Figure C.12 Schematic plan of Sample 12 displaying primary, secondary and circulation spaces.

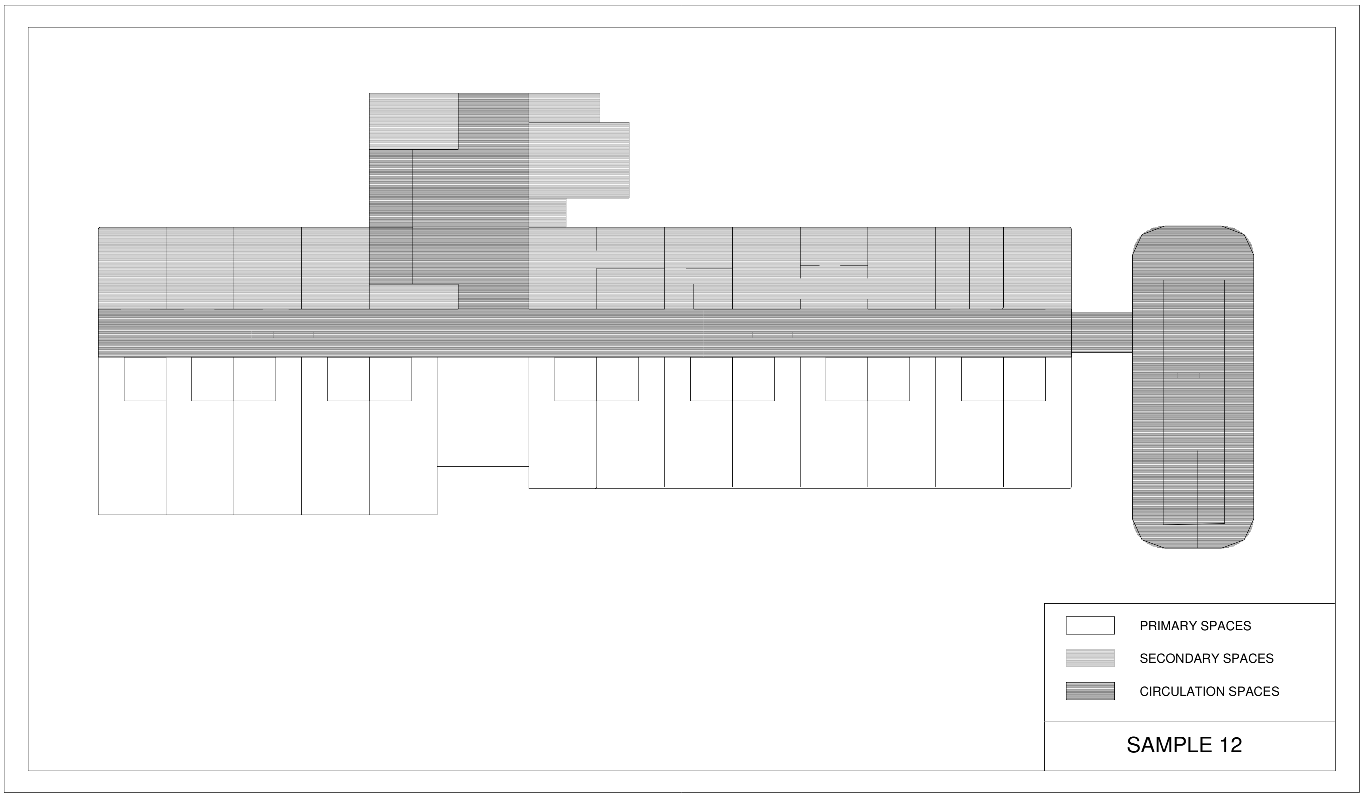


Figure C.13 Schematic plan of Sample 13 displaying primary, secondary and circulation spaces.

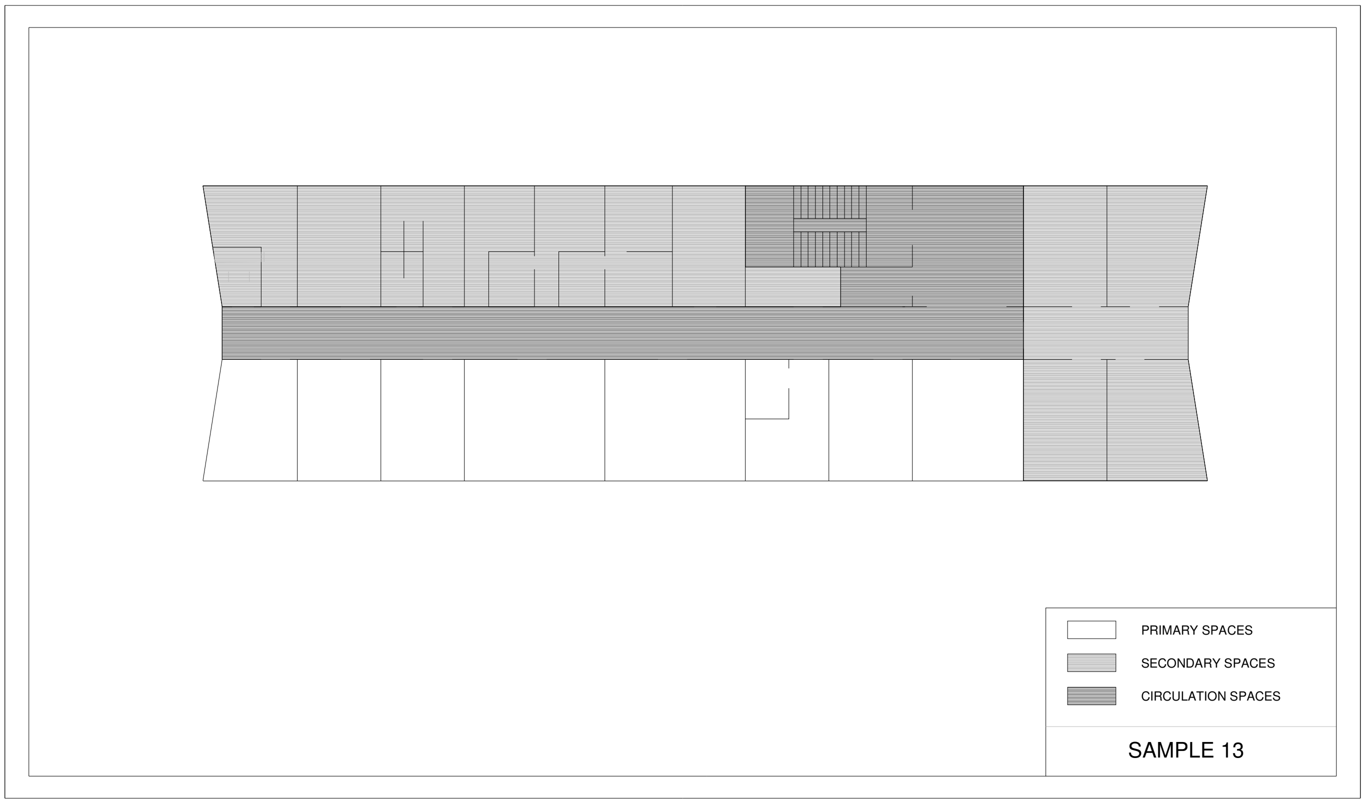


Figure C.14 Schematic plan of Sample 14 displaying primary, secondary and circulation spaces.

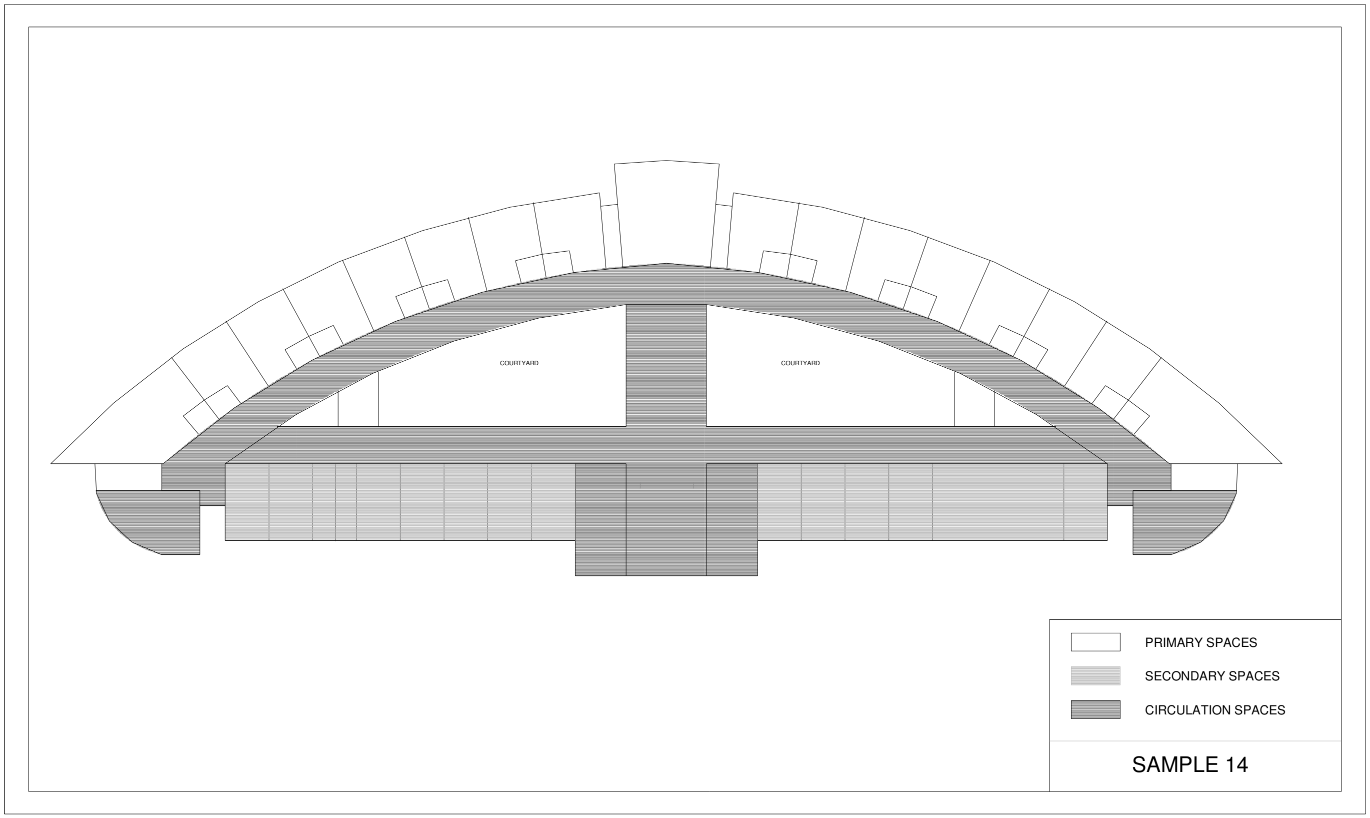
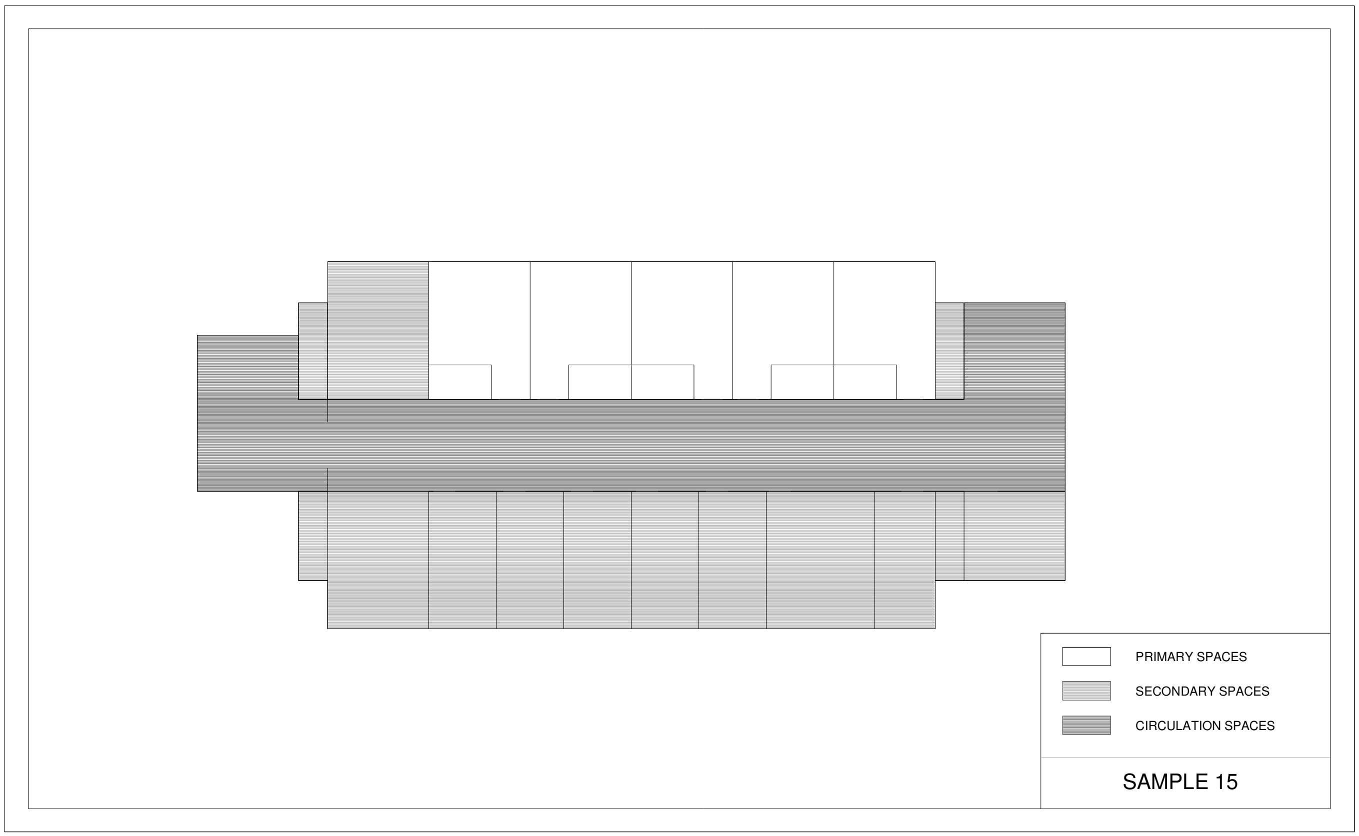


Figure C.15 Schematic plan of Sample 15 displaying primary, secondary and circulation spaces.



CURRICULUM VITAE

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FOREIGN LANGUAGES

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PUBLICATIONS

1. Kazanasmaz T. and Düzgüneş A. "Effectiveness of Lighting Systems for Patient Rooms and Corridors", Architectural Science Review, 47(3),215-221 (2004)

2. Kazanasmaz T. "Sağlık Yapılarında Aydınlatma", Modern Hastane Yönetimi, 7(1),14-23 (2003)