

FACTORS INFLUENCING THE DESIGN OF SPATIAL LAYOUTS IN HEALTHCARE BUILDINGS

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There has been a significant increase in capital building programmes in the National Health Service (NHS) since the publication in 2000 of the Government policy on modernisation of health and care delivery in the UK. With regard to physical capacity, the target was to create over 100 new hospitals by 2010 and 500 new one-stop primary care centres. The initiative was seen as a way to modernise the physical facilities as well as the key health and care delivery activities that take place in and around them. Space layout design is considered as one of the primordial activities in a building's lifecycle and impacts on the 'human to environment' and 'human to human' interactions. It is, therefore, essential to understand the factors that influence the design and outcome of space layouts, in particular in healthcare buildings because of the complex functional relationships that exist between the activities. A comprehensive review of the factors related to space layout design in healthcare facilities have been undertaken in this research. The findings suggest that the developments in healthcare and allied fields have implications for the design of space layouts and the resulting buildings and are as important as some of the functional aspects such as efficiency and productivity. The other notable factors can be attributed to the need to mitigate the impacts of, as well as adapt to, the global climate change.

Keywords: healthcare space layout planning.

INTRODUCTION

The National Health Service (NHS) is free at point of use and paid for out of taxation, delivering local service by 1.3 million staff in more than 300 organisations and through approximately 5200 GP practice premises as well as other primary care services (DOH 2008). The core of the services is the physical infrastructure that have been built mostly after its inception in 1948; more are still required and is now challenged by issues such as reducing economic growth, ageing population (Hosking and Jarvis 2003) and the need to conserve energy. There are also issues such as the greater accountability of public funding and increasing expectations from the stakeholders, mainly the patients regarding the service they receive. The NHS is also under pressure to reduce the cost of service delivery. Therefore, it is necessary to rethink the process of design and construction of new hospitals and adaptation of existing ones, in particular the decision-making during early stages. Decisions regarding the physical characteristics of a building such as layout, form, fenestration are made at an early stage and it is difficult to alter or reverse them later without significant financial involvements. Space layout design is considered as one of the primordial activities in architectural design for new construction and in most cases of building adaptation. Layout design is a process of locating activity spaces or objects in

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a container space to maximise or minimise design goals while satisfying the required spatial relationships among component spaces or objects. Design of space layouts in healthcare buildings is challenging due to its strict and complicated relationships among component spaces and/or functional units. The relationships can be in the form of preferred adjacencies and accessibilities. However, little research has been carried out on determinants of space layout plans in healthcare buildings. The aim of the research reported here is to investigate the factors that influence the design of space layouts in healthcare buildings.

METHODOLOGY

The research is based on a critical review of the state-of-the art in current practices in healthcare building design, healing aspects of the built environment, advances in space layout design and relevant policies and strategies of the NHS and Department of Health (DoH). Several strategies were employed to identify potential studies/articles for the review. Metalib, an information portal has been used to identify relevant catalogs, reference databases, citation databases, journals and conferences through semantic meta search. Keyword search was conducted in the identified databases which included but not limited to: the Online Computer Library Center (OLLC), Construction Information Service (CIS), the American Institute of Architects (AIA), British Library's Electronic Table of Contents (Zetoc), ScienceDirect, IngentaConnect, DoH portal, etc. Relevant journals, magazines and newspapers in the topics of healthcare design, patient safety and patient recovery were identified as well. A detailed review was conducted on the 51 of the 150 literatures, screened and identified through the method described above. The objective was to understand the factors that can influence the design of space layout in healthcare buildings.

Table 1: Stakeholders, their expectations from spatial configurations and impacts on the outcomes.

Stakeholders	Specific requirements	Impacts
Patients	Isolation from other patients (when required)	PD, IC
	Company of other patients (when appropriate)	PS
	Easy access to lighting, bed and television controls	PS
	Easy access to phone	PS
	Interesting area for ambulation	PS
	Outside view	PS
	Easy access to nurse's call signal	PS, PR
	Access to bathroom and shower	PS, PSa
	Pleasant indoor light	PS, PR
	Aesthetic, pleasing environment	PS, PR
	Ability to accommodate differing approaches to staffing	SP
	Ability to deal with shift in severity index	SP
	Ability of all care providers to confer in privacy	SP
	Nursing staff	Ability to work effectively in day or night shifts
Access to office and conference space		SP, SS
Access to information retrieval and input		SP, PR
Access to high-urgency/frequent-use items		SP, PR
Access to supplies and disposal of used supplies		SP, PR
Access to equipment storage in designated spaces		SP, PR
Access to medication		SP, PR
Staff lounge facility		SS
Security- personal and for property items		SS
Visitors	Easy access to patient's room	PS
	Private space for communication with staff	PD
	Accommodation with patients	PS, PR

Legends: SP: staff productivity, SS: staff satisfaction, PS: patient satisfaction, PSa: patient safety, PR: patient recovery, PD: patient dignity, IC: infection control.

FACTORS INFLUENCING THE DESIGN OF HEALTHCARE SPACE LAYOUT

Design of healthcare facilities has, in the past, concentrated mostly on accommodating the physical requirements of space and service delivery. The consideration of non-tangible benefits to the users such as patients, staff and visitors was mostly ad-hoc. Advances in our understanding of the therapeutic impacts of the built environment have led to a better appreciation of users' needs and their relevance to patient wellbeing and recovery. The focus is now on patient-centred design of healthcare facilities while considering the advances in recovery technology and changes in the organisation and service delivery. Studies have indicated that the physical environment, composed of how various activities are laid out, is linked with all indicators described earlier. Factors that influence the design of space layouts in healthcare facilities are described in the following sections and summarised in Figure 1. Various stakeholders, their expectations from spatial configurations and the impact of the factors on the outcome is summarised in Table 1.

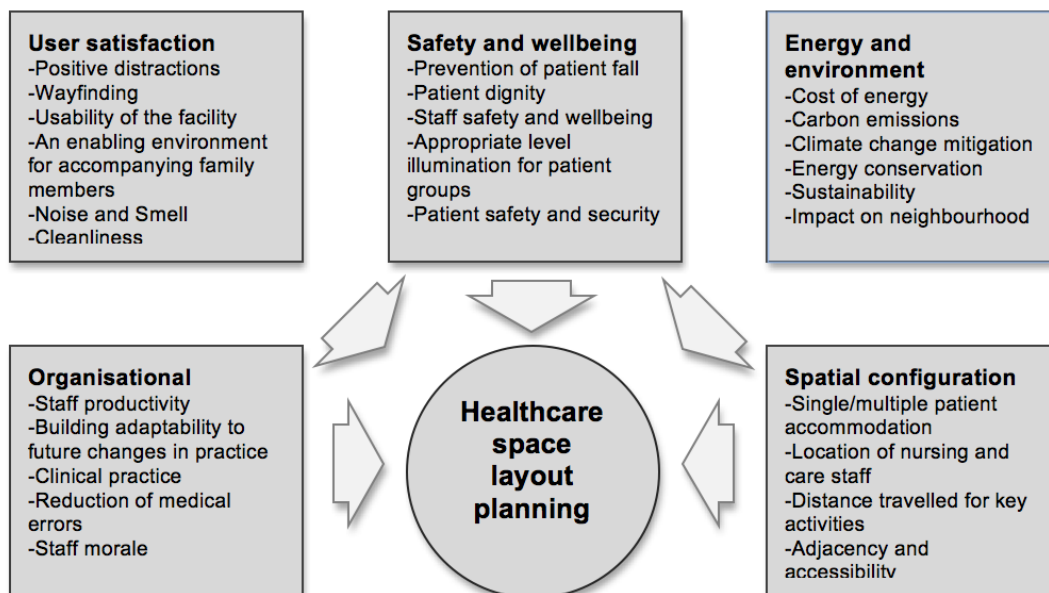


Figure 1 Factors that influence space layout design in healthcare facilities.

SAFETY AND WELLBEING

Patient safety. Patient safety has been considered as one of the most important aspects in the hospital design process and it relates to staff, patients and visitors. For patients, a safe environment is essential for successful recovery for staff safety relates to the working environment and their wellbeing. Evidence on the link between the facilities design and patients' safety can be found in the literature (Reiling *et al.*, 2004; Barach and Dickerman *et al.* 2006; Rashid 2007). Safety of staff and patient is of particular importance in the design of behavioural health facilities, as discussed by Sine and Hunt (2009) and summarised in the following five-level form:

- Level 1: Restrictions on accessibility; e.g. staff and service areas where patients are not allowed;

- Level 2: Highly supervised areas; e.g. corridors, counselling rooms, interview rooms and smoking rooms where patients are highly supervised and not *let alone* for periods of time;
- Level 3: Generally supervised areas; e.g. lounges and activity rooms where patients may spend time with minimal supervision;
- Level 4: Minimal or no supervision areas; e.g. patient rooms (semi-private and private) and patient toilets where patients spend a great deal of time alone with minimal or no supervision; and
- Level 5: Administrative or initial assessment areas; e.g. admissions rooms examination rooms and seclusion rooms where staff interact with newly admitted patients that may present potential unknown risks and/or where patients may be in a highly agitated condition.

The levels of safety, described above depends on the amount of supervision that the patients get from the staff during their stay. Hospital layout designs based on an assessment of staff and patient safety will aid the staff offer better supervision and reduce potential medical errors. The aspects of health and safety legislations and the management's desire to minimise risk from litigations also contribute to the safety aspects of design.

Patient falls. Another aspect related to patient safety is patient falls. Findings from literature suggest that most patient accidents take place in their rooms. Hendrich, *et al.* (1995), for example, discovered through a case study at a teaching institution that most falls occur when the patients would like to get to the bathrooms from their rooms. Pullen *et al.* (1999) reported that 74 out of the 444 patient falls in their study happened when the patients were alone in the bathrooms. The issue of patient fall have implications in the desired occupancy of patient areas. Multi-occupancy areas have higher concentrations of staff visit and therefore more safe with regard to falls, but it conflicts with other design goals such as patient satisfaction, etc. Another way to approach the issues to would be to increase the monitoring of patients by staff members (Hendrich *et al.* 1995), which may not necessarily be preferred due to the desire to drive down cost of service delivery. Allowing family members to accompany the patient has also been suggested (Ulrich 2004) to reduce the risk of fall. All of these approaches have bearings on the design of the hospital layout as activities, spaces and users are interrelated in a complex web of interaction.

Current practices related to patient safety has been criticised by the DoH, which concluded that contemporary facilities design is out of step with the thinking and practice in the NHS and is not as up-to-date as other safety critical industries or organisations (DoH 2003).

USER SATISFACTION

Patient satisfaction

Evidence from recent literature indicates that patients expect more from the hospital in addition to a high quality of health service, such as spacious single bedroom with bathroom, pleasant lighting, ability to have outside views, access to phone and television controls, etc. There is a strong link between patient outcome and what patient want in a building, further discussed in Ulrich (2004) and Lawson and Phiri (2004). Some of the features of patient satisfaction are discussed below:

Accommodating visits from family members. Visits from family members will provide social support to the patient, which may help to alleviate the physical pain and

stress. It has been found that the involvement or interaction of family during hospital stay affect patient outcomes (Powers and Rubenstein 1999).

Occupancy. Barlas (2001) argues that the noise disturbance increases stress levels and disturbs sleep patterns among patients and slows down patient recovery as a result. Single rooms are, therefore, preferred to multi-bed wards as they provide the patients a more quieter environment as well as increased privacy and confidentiality. Frequent family interactions is more acceptable in single rooms.

Positive distractions. Positive distractions have been defined as "environmental-social conditions marked by a capacity to improve mood and effectively promote restoration from stress" by Ulrich (1991). Aspects such as outside views, pleasant lights, music and art will all enhance the patient wellbeing. Positive distractions are also known to improve staff morale and satisfaction.

Patient privacy

A survey by Jones and Bullard (1993) of 140,000 hospital patients showed privacy to be of primary concern to patients. Healthcare providers have a duty to treat patients with respect and autonomy and to protect their personal data and the physical person from the invasion of privacy.

Single-sex accommodation. Being with other patients of the same gender is an important component of privacy and dignity. This type of accommodation can take a number of different forms, for instance, the single-sex wards, single-sex bedded bays and single rooms. The hospital should provide a combination of these different types of accommodation. Recognising the importance of the aspect, the DoH has been slowly replacing mixed wards with single-sex wards over the past years. 97% of NHS trusts provide single-sex wards with segregated bathroom facilities.

Dignity on the ward. In addition to the segregation based on sex, the patients prefer to have the ability to make their personal space private as and when necessary. The image of a hospital ward featuring a line of beds with no physical separation between them, also known as a 'Nightingale' ward fails to provide the essential levels of privacy. 98% of these wards for older people have now been replaced as part of a wider hospital building programmes. Over 350 other Nightingale wards have also been replaced (DoH 2001).

ORGANISATIONAL

Reducing errors. Research has shown that people are likely to make mistakes when busy, tired or at worse body conditions. Errors may occur at the ill-designed nursing stations, disorganised and/or filled storage rooms. Cortvriend (2005) has found that the nursing staff pick up a wrong bottle or put the bottle at the wrong place because of the non-distinguishable storage design for medicines.

Clinical practice. The drive to reduce costs of service delivery and the advances in clinical practice have implications on the way hospital layouts are designed and constructed. The design of layouts also need to be adaptable to future changes in practice, in particular because of the integration of information technology (IT) and virtual activities such as virtual surgery, telemedicine, etc.

Nurse station. The impacts of hospitals on the staff are studied extensively, in particular the aspects related to nurses' productivity. Nurses' station is regarded as the primary determinant of the architectural form and character of hospital buildings (Kazanasmaz 2006). The function of the nursing unit is the organisational hub of the

patients ward where the nurse-call is registered, paperwork is done and staff report at change of shift. A good design of the nursing unit will help to improve patient care and staff satisfaction (McCarthy 2004). This aspect is discussed further in the next section.

SPATIAL CONFIGURATION

Infection control

Hospital design should make sure that the inpatients, especially those vulnerable and weak, are away from the infection within the hospital. Several studies indicate that the effectiveness of frequent hand washing and after each activity with associated risks of infection. Spatial configuration with single-patient accommodation have also been found to be effective in containing infection and reduce the risk of spreading (Chaudhury *et al.* 2006, Dowdeswell *et al.* 2006, Saxon 2004, Ulrich *et al.* 2004). However, it needs to be mentioned that the degree of effectiveness of single-patient accommodation in reducing levels of hospital infection is not based on any large scale longitudinal study. Contrasting findings also exist; e.g. Vietri *et al.* (2004) investigated the effects on MRSA infection rates of moving from a hospital with open bay wards to a new facility with single or double rooms. No significant change of MRSA infection rate was found; this is interesting but it covers only one hospital that includes a relatively small group of patients. Lawson and Phiri (2004) argue that it is easier to detect and manage infection outbreaks at single-patient rooms because:

- Single-patient rooms act as isolated units in the hospitals;
- It is relatively easy to carry out deep cleanings in single-patient rooms;
- Monitoring of single patients with infection is more manageable;

Evidence concerning the efficacy of treatment of patients in single rooms mainly concerns quite specific categories of patients such as SARS infected patients (McManus *et al.* 1994; Thompson *et al.* 2002; Farquharson and Baguely 2003; Schwarz and Dulchavsky 2002).

Space considerations

Bed space. The provision of sufficient space in clinical areas, in particular around each bed, is one of the most important aspects of the design of acute in-patient accommodation for allowing for key activities as well as to reduce infection risks. The relationship between the bed spacing and infection carriage has been examined by many researchers (Kibbler *et al.* 1998, Williams 1966, Saxon R 2004). They argue that if adequate space around a single bed is not provided, the equipments may become contaminated and may lead to cross-infection if they are relocated elsewhere. Lawson and Phiri recommended that the minimum area of single-patient rooms should be 20 m², with dimensions of 5m by 4m, excluding en-suite facilities; similar to what has been suggested in the Health Building Notes (HBN 1997).

Nurses' station. The location and configuration of the nurses' station impacts on patient observation and safety, efficiency of service delivery, travelling time and to some extent staff satisfaction. Visibility of the Nurses' station to the patients have been found to be important in maintaining a good level of service. Figure 2 depicts popular types of nursing stations and their impact on the layout and architectural form.

ENERGY AND ENVIRONMENT

Energy consumption cannot be overlooked when design the healthcare layout as the health care sector is one of the public sector's largest energy consuming sectors with

an annual energy bill of £400m and emissions of 3.3MtCO₂/yr (Carbon Trust 2007). The sector has mandatory energy targets for new and existing buildings, which seek to deliver a 15% reduction in energy consumption from 2001-2010. Well thought-out layout design may prevent unreasonable energy consumption to enhance the overall sustainability of the building and contribute to climate change mitigation. Attempt has been made by the NHS in recent years to decrease the amount of energy consumed within their premises and, consequently, greenhouse gas (GHG) emissions.

DESIGN PROCESS CONSIDERATIONS

This paper addresses the general issues that influence the design and in some case, the operation of healthcare buildings. The findings in this research suggest that the developments in health and care delivery and in the allied fields have implications for the design of space layouts and resulting buildings, which are sometimes as important as some of the functional aspects such as efficiency and productivity. Apart from the factors described above, the design of healthcare buildings is much influenced by the dynamic developments in the changing healthcare sector, from the financing of the sector to the perception and/or satisfaction of the key stakeholders. Adaptability to future changes, both organisational and technological, is therefore the key to the design and construction of sustainable healthcare buildings. Typically, the design of healthcare buildings is driven by their function and the type of services that they provide to the public. The wider recognition of the healing aspects of the built environment translates to the fact that the design of a hospital, from layout planning to the detailed design of its services, need to be holistic in its approach.

The consideration of the wide range of factors that may affect the outcome of a healthcare building is challenging in an industry setting. Therefore, a strong collaboration among the stakeholders at the earliest in the process is essential to maximise the positive outcomes and to enhance sustainability. Integration of multi-disciplinary simulation and modelling tools for analysis and optimisation methods for an effective search of the design solution space may assist designers and other stakeholders in making effective decisions.

CONCLUSION

The influence of a hospital's design on patient wellbeing has been subject to much debate throughout the past 150 years (Gidney 2008). As more patient-focused healthcare facilities are being built, ensuring patients' wellbeing is not the only standard a modern hospital should aim for. Besides the clinical aspects, the healthcare environment around a patient plays a very important role during their stay. A well-designed/refurbished hospital is, therefore, the cornerstone of the high standard the government is aiming to achieve. The consideration of the factors identified in this research are essential in the process of design/refurbishment. The complex and often conflicting interrelationship that exist between some of the factors may require the stakeholders to work collaboratively during all lifecycle stages, starting from inception or concept development.

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