

Evidence-Based Design: The Effect of Hospital Layouts on the Caregiver-Patient Interfaces

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Abstract

Evidence-based design (EBD) takes information from credible research and case evaluations into account for design-related decision-making. Despite a wealth of studies in healthcare buildings, EBD has so far considered hospital layouts and their effects only marginally. Therefore, this study contributes to the EBD of hospitals by studying configurational issues. It focuses on how a building layout can affect communication between people that is crucial for good healthcare provision. Two types of interface created between users in outpatient clinics are analysed: caregivers-patients and caregivers-caregivers by comparing spatial layouts across two very differently organised hospitals. The two settings are compared using 'Space Syntax' as a methodology; this is brought together with findings from a staff survey identifying communication networks and direct observations on everyday activities of caregivers.

Results suggest that by providing shared facilities and bringing caregivers together, communication is more frequent. Creating a clear spatial separation of staff and patient areas facilitates good communication, both among caregivers and between caregivers and patients. However, space is not the only factor affecting communication, since other aspects such as workflow or culture also have an effect on interaction patterns between users. In summary, configurational issues matter and should be studied further by researchers in the field. The paper adds to the existing body of evidence in the field of healthcare and thus enhances the current understanding and knowledge of practitioners on the influence of the built environment on people. Implications for architects and designers in healthcare are discussed briefly.

Keywords: evidence-based design, hospital layout, communication patterns, Space Syntax

Evidence Based Design: Application Problems and Gaps

Evidence-based design (EBD) enables designers and architects to base design decisions on the best available information from credible research and evaluation of existing projects (Hamilton, 2006). It is suggested that using EBD professionals can ensure well designed physical environments that may help patient safety and improve patients and staff outcomes (Ulrich *et al*, 2004). EBD stems from evidence-based medicine (EBM), which is defined as 'the use of mathematical estimates ... derived from high-quality research on population sample to inform clinical decision-making in the diagnosis, investigation or management of individual patients' (Greenhalgh, 2010). EBM is built upon a very well established scientific and theoretical basis and uses well-constructed methodologies. EBD is relatively new and clearly seeks to create an evidential foundation that goes beyond anecdotal evidence.

In a systematic review of the research literature on evidence-based healthcare design Ulrich *et al* (2004) identified more than 600 'rigorous' studies. However, if the appendix to their paper is looked at closely, the authors included studies with low methodological rigor in their review (Sailer *et al*, 2008). Four years later, the research team conducted a new and more extensive search for empirical studies and found a growing body of research (Ulrich *et al*, 2008). In this second report, the authors have substantially revised and expanded the scale of most sections. This time they addressed the limitations of the quality of existing evidence themselves, stating they have included 'many studies [which were] not well controlled'. It is hard though to produce 'controlled trials', as most changes of the physical environment could alter several factors simultaneously making it hard to identify the independent effect of the change of interest (Ulrich *et al*, 2008).

Ulrich *et al* (2004; 2008) mainly identified studies with a focus on environmental issues such as noise, light and air quality. In cases where the layout of the building was of interest various aspects were studied including (among others) single versus multi-bed rooms and their effects on reducing falls, preventing infections, providing better privacy, less noise and facilitating communication. However in these studies the layout was either rather generally defined (radial, single or double corridor ward) or not taken into account at all (Sailer *et al*, 2008). Therefore, a major gap in the practice of EBD is the lack of research that studies buildings' configuration and its influence on patients and staff.

To compensate for this lack of studies, this paper builds on the tradition of Space Syntax research as a theory and method that is designed to allow a rigorous and systematic way of studying the built environment and its influence on people. In this approach every building defines an interface that is the spatial relation between or amongst two broad categories of persons: inhabitants, those who have some degree of control of space and visitors who lack control (Hillier and Penn, 1991, Hanson and Hillier, 1984). Space generates and controls encounter between these two groups and thus influences communication patterns (Allen and Fustfeld, 1975; Penn *et al*, 1999; Rashid *et al*, 2006; Sailer and Penn, 2007; Sailer and Penn, 2009).

Traditionally activities in hospitals were considered to be rather programmed than configurational and thus not affected that much by the building layout (Hanson and Hillier, 1984). However in recent studies it was argued that the configuration of healthcare buildings could influence people's movement and interaction (Lu *et al*, 2009, Heo *et al*, 2009, Cai and Zimring, 2012, Koch

and Steen, 2012b, Koch and Steen, 2012a). It was also shown that levels of programming in hospital settings can vary significantly (Sailer *et al*, 2013).

Therefore this study focuses on configurational issues to contribute to the relatively small but growing body of recent literature that studies the relationship between healthcare buildings and people's behaviour. A well-constructed multi-layered methodology, aligned with Sailer's framework for EBD (Sailer *et al*, 2008), is applied to the two types of interface created between hospital users in outpatient clinics: caregivers-caregivers and caregivers-patients. Communication patterns are of interest in this study because through communication people exchange knowledge and information and consequently this has an impact on the quality of the provided healthcare (Donchin *et al*, 1995).

The research questions addressed in this study are: 1) How are the different interfaces in hospitals constructed spatially? 2) How does the spatially constructed interface affect communication patterns and thus care provision?

The argument will proceed in the following steps: section 2 presents the case studies; section 3 introduces the methodology used; section 4 highlights the main results of the study and a final section 5 discusses the findings and reflects on the practice of evidence-based design.

Case Studies

Communication patterns in two different hospitals were compared. Five corresponding outpatient clinics in each hospital were selected for comparison. The two hospitals were specifically selected to contrast in their setup and spatial organisation. While Hospital A stands for a new and innovative model of healthcare provision, Hospital B is more traditionally organised.

Hospital A is a new and large stand-alone building located at the outskirts of a small town in the Netherlands. The main entrance of the building leads to a large atrium where receptions and waiting areas are situated (fig.1). The clinics are located on the first two floors on both sides of the atrium. Figure 3a shows the layout of one of the clinics. Clinics are co-located and have a clearly defined large and shared area for professionals called the 'Knowledge Centre' (fig.1). This area is located on a half level in-between the two outpatient clinic floors and accommodates open-plan workplaces with shared desks and facilities such as meeting rooms, quiet rooms, tea points and printing areas.

In contrast, Hospital B is structured as a campus of several buildings, located in the centre of a big city on the West Coast of Canada. It was first opened in 1912 and refurbished in several stages. The complex has two main buildings with links connecting the buildings on the first four floors. The five studied clinics are located on the fourth, fifth and eighth floor of the building. Figure 3b shows the floor plan of one of the clinics as an example of a traditionally structured corridor based layout. Physicians in Hospital B have either single or shared offices for two to three people. In some of the clinics there are also clinic-internal teamwork areas.

There are two major differences between the layouts of the clinics that reflect on the interface between staff and patients and amongst staff. The first one is that in Hospital A the back- and front-of-house areas are strictly separated while Hospital B is more traditionally structured with a

system of corridors that connects waiting areas with exam and consultation rooms (fig.2). The second difference is that in Hospital A the clinics are co-located and have a shared work area – the ‘Knowledge Centre’ while in Hospital B clinics are separated and do not have shared facilities. Therefore, in Hospital A caregivers are brought together with each other and are separated from patients while in Hospital B caregivers are separated from each other but brought together with patients.



Figure 1: Hospital A – patients waiting area and reception; the Knowledge Centre;



Figure 2: Hospital B – patients waiting area and reception; a corridor;



Figure 3a and b: Floor plan of Surgery in Hospital A and B

Methodology and Metrics Used

Three distinct methods were combined in this paper. Space Syntax was used to analyse the spatial configuration of the buildings. Social Network Analysis was employed to study results from an online survey of communication patterns. Direct observations of activities were conducted to gather quantitative data on social life in the two hospitals.

Space Syntax represents the continuous flow of space as a series of linked elements, for instance rooms and corridors in a building are connected by doorways or staircases. Axial models of the clinics were constructed using Depthmap software (Turner, 2010, Varoudis, 2012). Axial line maps can be defined as the least set of straight lines covering all parts of the building, thus all routes of movement and making all links necessary to represent the relationship between people through space (fig. 4). The metric axial step depth was used to measure the distance between two axial lines as the number of axial steps that one needs to take to get from one space to another.

A staff survey including a Social Network Analysis was conducted in both hospitals to quantitatively assess communication patterns amongst caregivers. 177 and 206 physicians, nurses, clerks, residents and allied professionals from Hospital A and Hospital B respectively were invited to participate. The return rate for Hospital A was 31% and for Hospital B 43%. In the first part of the survey participants were asked to rate the importance of required work activities on a scale from 1 to 7 and to rate how much the spatial layout of the hospital supported these activities. In the second part of the survey they were asked to select up to 25 colleagues and to indicate on a scale from 1 to 7 how often they communicated face-to-face planned, face-to-face unplanned and electronically. Results were analysed with UCINET (Borgatti *et al*, 2002).

Observations were conducted by following six different caregivers each day for ten working days in each hospital (two days dedicated to each clinic). In total 128 members of staff were observed (64 physicians, 33 nurses and 31 clerks), each for a period of 1.5-2 hours during examination hours. Sequences of activities and locations, durations and types of activities were digitally recorded. Pre-programmed PDAs (Personal Digital Assistants) were used for the data collection. Differences in time spent in certain activities and locations between the two hospitals were analysed.

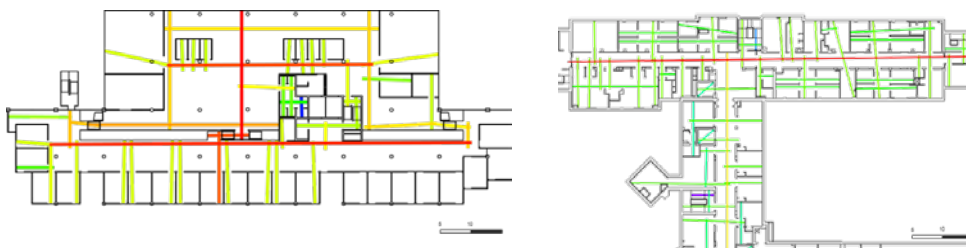


Figure 4a and b: Axial maps of Surgery in Hospital A and B

Communication and Encounter Patterns

This section will investigate communication and encounter patterns for both interfaces mentioned: firstly the interface caregiver-caregiver will be analysed, and secondly the interface caregiver-patient.

In Hospital A caregivers are co-located and physically brought together in the open-plan area of the Knowledge Centres. During exam hours, caregivers spend 69% of their time in the charting galley, adjacent corridor and knowledge centre (with 21% of their time spend in the exam rooms). This means during the majority of their working day, caregivers are available and accessible to interact and communicate with each other. Moreover the separation of back and front-of-house allows caregivers to consult other staff members freely without worrying of being overheard by patients. Indeed, one of the best features mentioned in an open question by 14% of participants in Hospital A was the back-of-house, where they can easily interact with other caregivers. 19% of time during exam hours is spent talking to colleagues internally and another 3% to external ones. An average conversation between caregivers within a clinic lasts only 44 seconds, which means communication is short, frequent and ubiquitous.

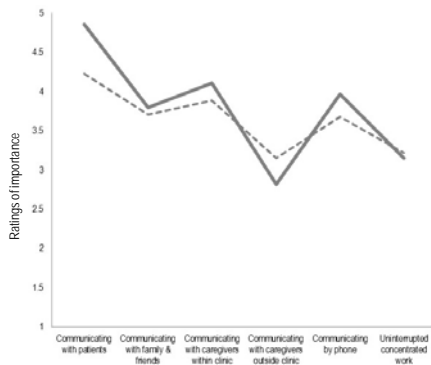
In the survey, communication to other staff inside the same clinic was considered as an important or very important activity by 79% of caregivers; communication to colleagues in other clinics was valued by 26% of staff. The building was rated as an enabling factor for the caregiver-caregiver interface (see figure 5a), since an average rating of 4.1 (on a scale from 1-5) was given to the spatial suitability for intra-clinic communication and 3.4 for inter-clinic communication. A potential area of dissatisfaction was concentrated work, since 29% of staff suggested that more private spaces were required. Still in this hospital, the importance given to an activity and the rating of the spatial layout match to a high degree.

The compact spatial structure of Hospital A results in high levels of proximity between the clinics so that distances between clinics are rather small and range from one to eight axial steps. This has an effect on communication intensity (as argued in more detail by Sailer *et al*, 2013): with the increase of distance between clinics, communication decreases logarithmically. Workflows and speciality of clinics were identified as confounding factors.

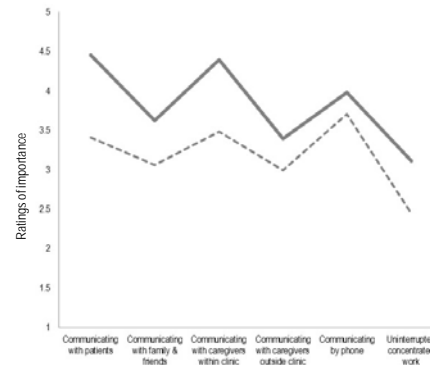
The integrative nature of the flexible and open work environment of Hospital A is also reflected in the workflow patterns of staff. As shown in figure 6a, physicians and nurses have a very similar activity pattern and spend comparable amounts of time in the same locations. Only clerks show a completely different pattern of occupation. This means the spatial layout acts integratively and brings caregivers together, resulting in ample opportunities for communication across the professions.

In summary, the caregiver-caregiver interface in Hospital A allows for frequent and intense communication between staff within as well as across the different clinics. Close proximity and an open-plan layout are facilitating factors.

Hospital A



Hospital B



— Importance of activities - - Spatial layout suitability

Figure 5a and b: Importance of different activities and suitability of the spatial layout for Hospital A and B.

In Hospital B caregivers are much more segregated by the partitioning of the traditional corridor-offices layout. During exam hours, caregivers spend only 46% of their time in teamwork areas and corridors (with a comparable 24% spent in examinations), so that in effect caregivers are not as openly available for communication and interaction as in Hospital A. While a similar amount of time of the working day (during exam hours) is dedicated to communication with 22% of time spent talking to caregivers in the same clinic and 0.2% to external caregivers, average conversation length is 1 minute and 21 seconds, i.e. twice as long as in Hospital A. This means each instance of communication lasts longer and is therefore in all likelihood more planned and less spontaneous.

Survey results in Hospital B are similar to Hospital A, as communication between staff is regarded highly: 85% think communication within clinics is an important or very important activity and 44% think the same for communication across clinics. However, the building seems less suitable: ratings of 3.5 out of 5.0 (intra-clinic communication) and 3.0 out of 5.0 (inter-clinic communication) were made regarding the question to which degree the spatial layout supports necessary workflows. Again, the ability to concentrate seems compromised and 16% of staff mentioned the need for more private spaces. The gap between importance of activity and suitability of the building is much wider for all activities, as shown in figure 5b.

The traditional spatial structure of Hospital B creates much greater distances between caregivers than in Hospital A. Axial step depths range from one to sixteen steps separating the different clinics from each other. The relationship found between distances and communication intensity in Hospital A does not hold in this case: it seems that other factors such as working cultures, workflows and specialism of disciplines are much more important in the face of a partitioned layout and particularly high vertical distances.

The segregating nature of the building also becomes apparent in workflow patterns (see figure 6b): in Hospital B physicians and nurses show more deviating patterns of occupation than in

Hospital A – the different professions tend to spend time in different places. This results in lower chances for communication and means a more disrupted interface.

To summarise, the caregiver-caregiver interface in Hospital B is characterised by longer and more programmed conversations focusing on relationships within rather than across clinics, and within rather than across professions. Higher spatial distances and the overall configuration contribute to lower ratings of satisfaction with the building.

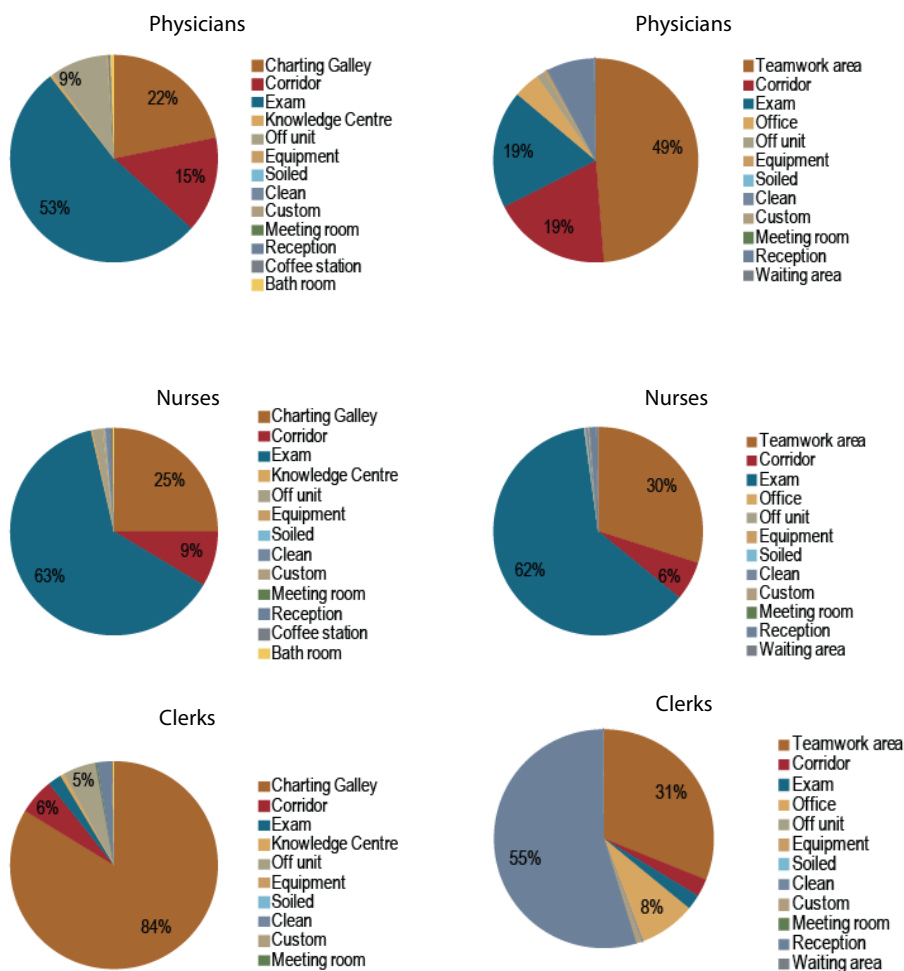


Figure 6a and b: Percentage of time spent in various locations by physicians, nurses and clerks in Hospital A and B;

Similarly to the differences in the caregiver-caregiver interface, the interface between caregivers and patients also varies between the two hospitals.

In Hospital A communication with patients is considered as the single most important activity in the work of caregivers with a rating of 4.9 (on a 1-5 scale). Even though the interface is highly

regulated spatially since all areas of the Knowledge Centre are inaccessible to patients, caregivers spend a lot of time with their patients (15% of time talking to and 5% caring for patients plus another 1% talking to family).

On the contrary, communication with patients is not quite as high on the agenda in Hospital B. Caregivers give it a rating of 4.4 and see it as equally important to communication with colleagues. Time spent with patients is a lot shorter than in Hospital A with caregivers spending only 4% of their time talking to and 7% caring for patients plus another 0.3% talking to family. However, another 5% of caregiver time is spent in phone calls with patients and again the need for more private spaces becomes obvious as the following quote exemplifies: *"I have gone into the bathroom and shut the door to take more than one difficult phone call in order to have some safe, quiet space for the patient calling"* (Allied Professional, Pacific Lung Clinic, Hospital B).

In summary, the interface between caregivers and patients is structured very differently in both hospitals. The secluded area of the Knowledge Centre in Hospital A, which is inaccessible to patients, creates a rather programmed spatial interface – patients and caregivers mostly meet in the exam rooms only and nowhere else. Still a lot of time is committed to patient communication and care. Hospital B in contrast allows for more random encounters between caregivers and patients on the jointly used circulation spaces, yet less time is spent with patients face-to-face.

Conclusion

This paper gives insights into the effect of the design of hospital buildings on people's behaviour. Two different hospital layouts were analysed and their implications on communication patterns of caregivers were discussed. It was shown how configurational choices and simple design principles (access, co-location, openness, proximity) have an impact on the creation of the caregiver-caregiver and the caregiver-patient interfaces and how this in turn affects communication and occupation patterns, which are an important factor in good care.

Integrating caregivers in an open area and segregating patients at the same time, as realised in the spatial layout of Hospital A, seems an innovative design choice resulting in intensive and frequent communication patterns all around.

Although very rich data was gathered for the present study some limitations should be noted. First, observations were done during exam hours in outpatient clinics only. Therefore the social behaviour in areas such as the Knowledge Centre or the public areas was not fully captured. Second, the return rates from the online survey were relatively low, which weakens our multi-layered data.

Still the rigorous methodological framework of this paper combining quantitative as well as qualitative data on spatial and social aspects allows new insights. This knowledge is important for architects and designers of healthcare buildings. Adopting an evidence-based approach and using insights from rigorous research can advance the provision of good healthcare by designing hospitals that ease communication among staff and allow staff to focus their attention on patient care. The spatial organisation of buildings influences communication patterns and as such configuration matters.

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