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Pre-Occupancy Evaluation of Patient Satisfaction in Hospitals

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ABSTRACT

Aim of the paper: To explore analytical drawing techniques as a means to assess the attainment of pre-set objectives in the design phase of hospital buildings and to test ex-ante if the building fits with these objectives, with a focus on view on nature, way-finding, daylight, visibility of patient areas from reception desks, privacy and communication between medical staff and patients, and noise reduction.

Background: The impact of the build environment on user-value is at the core of Evidence Based Design, but these values are normally only experienced by users after the building is constructed. Therefore, assessment of these values during the design phase could improve the outcome for patients.

Topical Headings: An analysis of available assessment tools showed that research by drawing and the use of Space Syntax methods is an adequate means to visualize the strengths and weaknesses of floor plans in relation to spatial user-experience. This approach is illustrated by an assessment of a nursing ward of the Deventer hospital in the Netherlands.

Conclusions/Recommendations: Floor plan analysis by using space syntax techniques makes it possible to visualize various aspects of user-value and supports the incorporation of usability issues in the discussion between the designer, the client and the users during the design process. It is recommended to test the findings of the design assessment by a Post-Occupancy Evaluation of the building-in-use and to conduct similar studies in other hospitals, as a means to build a body of knowledge for user-oriented design and management of hospital buildings.

EXECUTIVE SUMMARY

Only when a building has been built it becomes clear if the building works as expected and if the objectives of the clients, customers, end users and other stakeholders are attained. If not, it is difficult and costly to adapt a building-in-use to fit with the needs and interests of the stakeholders. This paper explores how some of the pre-set goals and objectives can be assessed ex ante, in the design phase, before it is built. The paper focuses on six aspects that are perceived as most important to support patient satisfaction: view on nature, way-finding, daylight, visibility of patient areas from reception desks, privacy and communication between medical staff and patients, and noise reduction (Ulrich et al., 2008). An analysis of available assessment tools showed that research by drawing and the use of Space Syntax methods is an adequate means to visualize the strengths and weaknesses of floor plansin relation to spatial user-experience. This approach is illustrated by an assessment of a nursing ward of the Deventer hospital in the Netherlands. This building has been built in the period 2004-2008 and is recognized as a leading hospital regarding hospitality.

INTRODUCTION: THE NEED FOR EX ANTE EVALUATION OF BUILDINGS IN THE DESIGN PHASE

Recent research on the added value of hospital real estate shows that **PATIENT SATISFACTION AND COST REDUCTION ARE HIGHLY PRIORITIZED VALUES IN MANAGING HOSPITALS-IN-USE** (Van der Voordt, Prevosth, & Van der Zwart, 2012; Van der Zwart, 2014). Post-Occupancy Evaluation (POE) of buildings-in-use can provide relevant information about the performance of a building from an end-user point of view (Preiser, Rabinowitz, & White, 1988; Van der Voordt & Van Wegen, 2005; Zeisel, 1984). Building Performance Evaluation (BPE) usually also includes an evaluation of technical issues and economic performance of a building (Preiser & Schramm, 2002, 2012; Van der Voordt & Van Wegen, 2005). However, in order to be able to test if the organization will attain its objectives regarding the building, it is of utmost importance that the building performance can be measured much earlier, preferably already in the design phase. After construction and being in use, it is much more difficult and costly to change a building than when it only exists on paper or in AutoCAD. However, because users can only really experience a building in reality, it is much less easy to measure its performance ex ante, before it is built, than ex post, when the building is occupied. This paper explores the impact of various tools for assessing architectural hospital design on patient satisfaction, in order to make this value visible and measurable in architectural design drawings. The purpose of which is to make these values debatable in the design phase of the decision process. As such this paper aims to show if and how different analytical drawing techniques can be used as a means to visualize and measure pre-set goals and objectives in the design phase. This paper explores the possibilities to visualize and measure aspects of patient satisfaction in the design phase by applying analytical methods and drawing techniques from literature. Design assessment will be discussed in relation to architectural design and Evidence Based Design (EBD). Both concepts will be related to architectural analytical techniques adopted from Space Syntax. Due to the highly experimental character of applying these Space Syntax techniques in architectural hospital design and in relation to Evidence Based Design, the choice is made to test the applicability of these techniques in this study on the level of one nursing department. Therefore, the theoretical background of these techniques are explained and illustrated by a case study of a nursing department of the Deventer Hospital in the Netherlands. The paper ends with conclusions, practical implications and recommendations for further research with the purpose to improve the techniques and test the representativeness of the visualizations in practice.

REVIEW OF LITERATURE AND APPLICATION OF EXISTING TOOLS

As part of a research into design and management of hospital real estate in a changing context (Van der Zwart, 2014), a literature review has been conducted of architectural and urban design analysis methods and drawing techniques, with a focus on techniques that can be used to assess patient satisfaction in architectural design drawings of hospitals. These drawing techniques have been applied to visualize various user-oriented qualities in different design drawings of a nursing department of the Deventer hospital in the Netherlands. This research by (re)drawing shows how the achievement of different aspects of patient satisfaction can be tested and pre-set values can be visualized. In particular techniques that come to the fore in space syntax literature showed to be promising to study aspects of use-value in design drawings.

DESIGN AND DESIGN ASSESSMENT

During the design process, organizational, social and cultural objectives are translated into spatial forms that are presented in floor plans, sections, facades and other architectural drawings. The drawing is a tool to represent a building, independent of whether it exists or not or not yet. **A DRAWING HELPS THE ARCHITECT AND USER TO UNDERSTAND THE ARCHITECTURAL FORM AND ENABLES TO DEBATE ITS QUALITIES.** It is the architect's task to provide drawings that clients and end users can understand and apply to assess whether the design fulfils their objectives. Drawings, 3D computer models, virtual walk-throughs and full-scale mock-ups can be used as well to support ex ante discussions and appraisal assessment of the spatial form with end users. Every architectural drawing can be regarded as a reflection of the goals and activities of the client and the users as interpreted by the architect (Van der Voordt, Vrielink, & Van Wegen, 1997; Van Hoogdalem, Van der Voordt, & Van Wegen, 1985). Floor plans are abstractions of real buildings and are the starting point for many architectural analyses (Clark & Pause, 2012; Moraes Zarzar, 2003). Architectural analysis of floor plans is not faithfully reproducing the object, but rather examining the architectural drawings on components crucial to the analysis, e.g. its composition, relationship between design and context, and the relationship between design, construction and usefulness (Leupen, 1997). Using the architectural drawing as an instrument to understand the meaning and underlying functional, social or spatial concepts is a particular way of 'research by design' or 'research through design' (De Jong & Van der Voordt, 2002) and is also called "research by drawing" (Steenbergen & Reh, 2012). De Jong (2002) showed how drawings can be used as a means to evaluate a design ex post and ex ante. He emphasized the importance of a clear legend that explains the used colors and graphics in the floor plans and a systematically transformation (or redrawing) of the original drawings in order to be able to compare designs in different contexts (De Jong, 2002). According to Leupen (1997) three basic methods are available for this systematic transformation of the original drawings: (1) Reduction; (2) Démontage; and (3) Addition. Reduction is the omission of all information that is not relevant to represent the main composition of space and material in order to disclose the structure of the design. Démontage refers to re-drawing the object by a decomposition of the different parts to reveal the relationships between the elements. Addition is introducing new layers of information into the drawings that are either non-visual or non-architectural, like movement of people and visibility of objects and areas. As such, research by drawing can be used as a method to conduct design research. This type of design research can be used for different purposes (De Jong and Van der Voordt, 2002). In educational settings it may help students to understand existing designs, its form and appearance, the spatial-functional lay-out, the technical construction and services, the impact of contextual factors such as legislation, policy issues and the economic context, and why the designer made certain decisions. During the design, construction and building-in-use phase this type of design research can also help to explore the effects of design decisions on the organization and the end users (Van der Voordt & Van Wegen, 2005). Ex-ante design research i.e. a review of the design before it is built enables designers to receive user feedback on the design at a stage where correcting mistakes and making improvements is relatively simple and not too costly. **RESEARCH BY DRAWING CAN BE USED AS A METHOD TO EXPLORE THE ATTAINMENT OF PRE-SET GOALS DURING THE DESIGN PHASE.** On a more generic level, this type of design research can add scientific knowledge and support evidence based design (EBD).

DESIGN ASSESSMENT AND EVIDENCE BASED DESIGN

EBD refers to design decisions that are based on the best available research and knowledge on that topic (Hamilton, 2009). One of the principles of EBD is that the scientific evidence resulting from Post-Occupancy Evaluations (POE) of existing buildings is used in the design decision process for new buildings. Evaluation of a building-in-use can make clear how the building is actually used and appreciated. This knowledge can be used as input into new design projects (Zeisel, 1984). A Literature review on EBD conducted by the Center for Health Systems and Design at Texas A&M University and the college of Architecture at Georgia Tech (Ulrich et al., 2008) came up with 600 studies on how hospital design can impact clinical outcomes. The review covers design issues such as single-rooms versus multi-bed rooms, way-finding, noise effects, sunlight, exterior views, mechanical installations and ergonomics. The authors plea for the use of EBD as a means to create healthcare buildings informed by the best available evidence regarding how the physical environment can interfere with or support the activities of patients, families, and staff (Ulrich et al., 2008). In this literature review, eight important aspects of patient satisfaction came to the fore: (1) view on nature; (2) daylight; (3) use of materials; (4) reducing noise levels; (5) way-finding; (6) visibility of patient areas from reception desks; (7) single patient bedrooms: and (8) ensuring privacy and communication between medical staff and patients. An important question is, how these aspects that are only experienced by patients in the actual buildings, can be measured in design assessments based on architectural floor plans? One method for floor-plan analysis that is often described and used is Space Syntax.

SPACE SYNTAX AS A METHOD FOR DESIGN ASSESSMENT

Space syntax was developed at the University College London by Bill Hillier and his colleagues and is based on the assumption that people's patterns of movement and interactions are directly affected by the geometry and network typology of spatial patterns of the built environment (Hillier & Hanson, 1984; Hillier & Ida, 2005). As people move within a building whilst performing their role-defined tasks, the configuration of the circulation network and the location of specific functional spaces within that network (the origins and destinations) generate a pattern of movement (Hillier & Hanson, 1984). Space syntax is a method that calculates the spatial configuration of built environments, especially public spaces. The spatial configuration is the pattern of spaces and relations between spaces which makes up buildings and cities (Hillier & Hanson, 1984). Space syntax therefore reduces the floor plan to an abstract network of nodes and links that represent the basic patterns of accessibility and circulation. Different spaces in a single building are differently embedded in these networks of nodes and links. The development of space syntax as a research method for analyzing spatial form resulted in different drawing techniques for analyzing architectural designs. Until 20 years ago, most calculations of spatial relationships in a network were conducted manually. Nowadays software programs have improved the possibility of analyzing the complex spatial relationships of public spaces and describing and visualizing spatial quality (Turner, 2007). These techniques for visualizing spatial quality focus on the connections between spaces, routing, sight-lines and visibility. Basic tools in space syntax analysis that can be used to assess how the building probably "works" are: (1) An axial map: a representation of the built environment by the fewest and longest sight-lines; (2) An isovist, that visualizes the view from a particular standing point in the built environment, not hindered by objects such as walls and columns; (3) Convex space, that divides the floor plan in separate more or less enclosed spaces and; (4) Agent Based Modelling, which uses computer software to visualize how agents (virtual persons) move through the floor plan finding their own way according to pre-programmed decisions.

OVERVIEW OF PREVIOUS RESEARCH USING SPACE SYNTAX TO SUPPORT HOSPITAL DESIGN

Design research using space syntax is relatively new in studying healthcare environments. Khan (2012) conducted a literature review to understand the contribution of space syntax to improve operational efficiency in healthcare design. He found several space syntax studies in hospital design, by Lu, Peponis, and Zimring (2009), Heo, Choudhary, Bafna, Hendrich, and Kaiser (2009), Haq (1999), and Setola (2009). These studies showed that visual and physical accessibility has significant effects on movement patterns, frequency of trips and way-finding. Walking distances and common routes taken by staff members showed to be largely affected by the design and layout of the hospital. The studies also showed that hospital design affects access to each and every department, with a direct impact on the movement of patients, staff and supplies. Peponis and Zimring (1996) concluded that in the past the design of hospitals was more focused on functional requirements of the hospital organization, and that this focus shifted over the years to the needs and experiences of patients. The applicability of space syntax in hospital design in connection with the building's life cycle costs was explored in a study by Kim and Lee (2010). This research compared three hospital wards on life-cycle user costs and shows how space syntax tools can be used to calculate connectivity, integration and visibility within a hospital plan. Various studies demonstrated that space syntax has the ability to predict deliberate use of space in way-finding situations. Peponis, Zimring, and Choi (1990) suggest that the way people try to orientate themselves by "exploring" the space can be predicted by the space syntax measure of integration. Based on observations of participants' search patterns and Space syntax analysis, the researchers found that participants tend to move along more "integrated" routes and not along the most direct paths or shortest routes (Peponis et al., 1990). Weisman (1981) showed that when the average number of connections per choice in a layout increased, people's cognitive mapping abilities and way-finding performance decreased. Heo et al. (2009) showed that connectivity is a significant factor in determining the frequency of trip and movement patterns in a hospital building. In the public areas of hospital buildings, the visibility of reception and information areas, the density of movement and position of lively and private spaces all have an impact on patient satisfaction (Peponis & Zimring, 1996).

TEST OF SPACE SYNTAX METHODS IN A CASE STUDY: THE DEVENTER HOSPITAL NURSING WARD

The new Deventer hospital opened in 2008. It is the only hospital that received a nomination for the Hedy d'Ancona Award for excellence in Dutch Healthcare Architecture. This is an indication that this hospital is recognized as a best practice for hospital architecture in the Netherlands. In 2011 the Deventer Hospital won the Dutch Hospitality Award, due to its policy to pay much attention to welcoming patients and visitors and to make them feel at home. Apart from the mother-child department and the intensive care unit on the first floor, all nursing wards of the Deventer Hospital are located on the second floor. The clinical beds on the second floor are divided into three wards of 84 beds. The wards are organized around three elevators. Each ward of 84 beds has 22 3-person bedrooms and 18 1-person bedrooms and is divided into two sub-wards of approximately 40 beds that share some facilities. Figure 1 shows the nursing wards on the second floor of the Deventer Hospital and a close-up of a sub-ward with eleven 3-person beds and ten single- bedrooms.

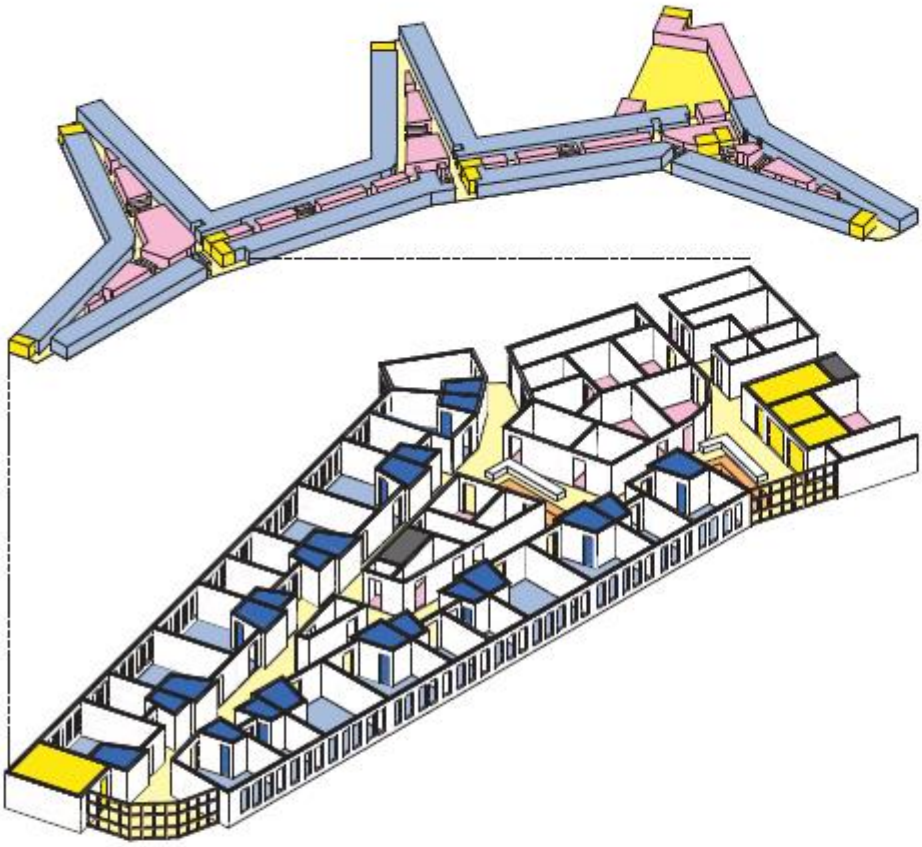

Figure 1, 3D model of the nursing wards on the second floor and one sub-ward.
light blue = patient rooms; dark blue = patient bathrooms; purple = staff rooms; yellow = elevators and stairs; light yellow = corridors; light brown = reception desks

Axial map analysis to assess way-finding support

An axial line represents the longest sight-line in space. An axial map is a representation of the built environment with the longest and fewest axial lines and represents the way people move through the network. This map is the basis for several spatial analyses. Four syntactic measures can be calculated that can be used in quantitative representations of a building or urban plan: (1) spatial connectivity; (2) integration; (3) control value; and (4) global choice. Connectivity measures the number of directly connected axes to an axis. Integration calculations are divided into global and local integration. Global integration refers to the number of direction changes needed to move from one axis in the network to all other segments. Fewer direction changes imply a higher spatial integration. Local integration refers to how integrated an axis is when changing direction three times from it. Today software programs are able to calculate this integration for every axis in the built environment (all-lines analysis). Control value measures the degree to which an axis controls access to other directly connected axes, taking into account the number of alternatives. A space has a strong choice value when many shortest paths that connect all spaces to all other spaces of a system, passes through it. **PEOPLE TEND TO ORIENTATE THEMSELVES BY FOLLOWING THE MOST INTEGRATED PATHS.** An axial map analysis of a hospital floor plan makes it possible to define the most integrated routes. In a design decision process, one can manipulate these routes by changing the architectural design of the floor plan and assess the impact of alternative designs.

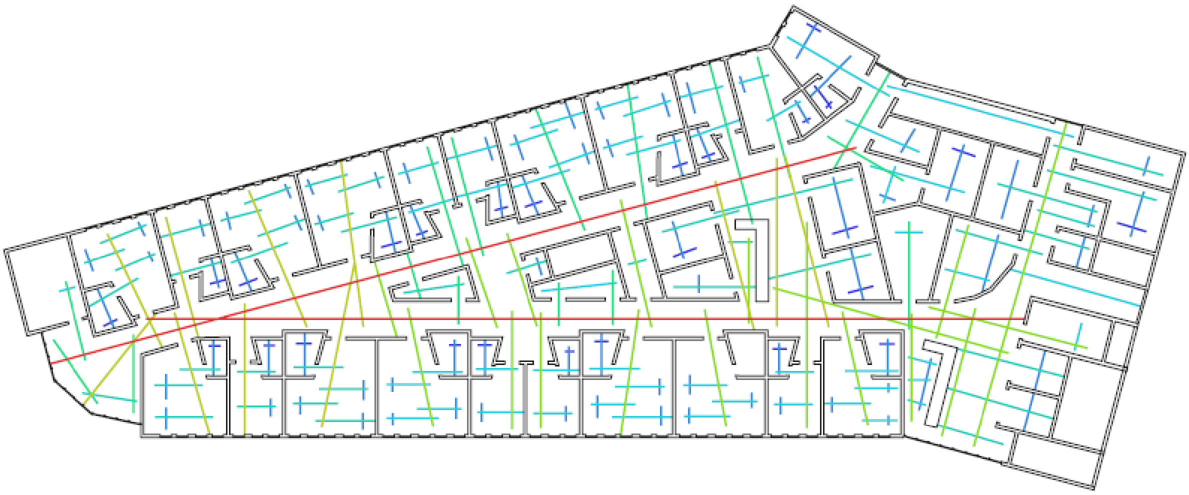

Figure 2, Axial map of local integration.
By a color spectrum from red-orange-yellow-green-light to blue-blue-dark blue, the local integration is made visible of all lines. The most locally integrated lines are the two red lines in the corridors.

Isovist analysis to assess view on nature

An isovist represents the set of all points visible from a given point in space (Benedikt, 1979). The shape and size of an isovist change when moving through space. As such it is possible to visualize the sequence of scenes or sightlines from particular points along the movement routes. An isovist analysis can be used to assess the view on nature from each room and the visibility of natural objects outside from each viewpoint in a room. With this technique it is possible to determine how many trees a patient can see, or how much from one tree, a wall, or parked cars. Combining and comparing this information makes it possible to determine the best outside view from each room. During the design phase, the outside view can be manipulated by designing different window sizes, re-positioning of the patient viewpoint in the room, or considering different orientations of the windows and rooms in relation to the surroundings. Another way to adapt the view on nature in the design phase is to change the positioning of trees in the direct surroundings of the hospital to make them well visible from different viewpoints in the hospital. Figure 3 shows the visibility of the opposite wall from the bedrooms at the right side of the nursing department. Figure 4 shows the visibility of a tree from inside the bedrooms. By using this analysis, the best positions of trees can be chosen in the design of exterior space related to interior space.

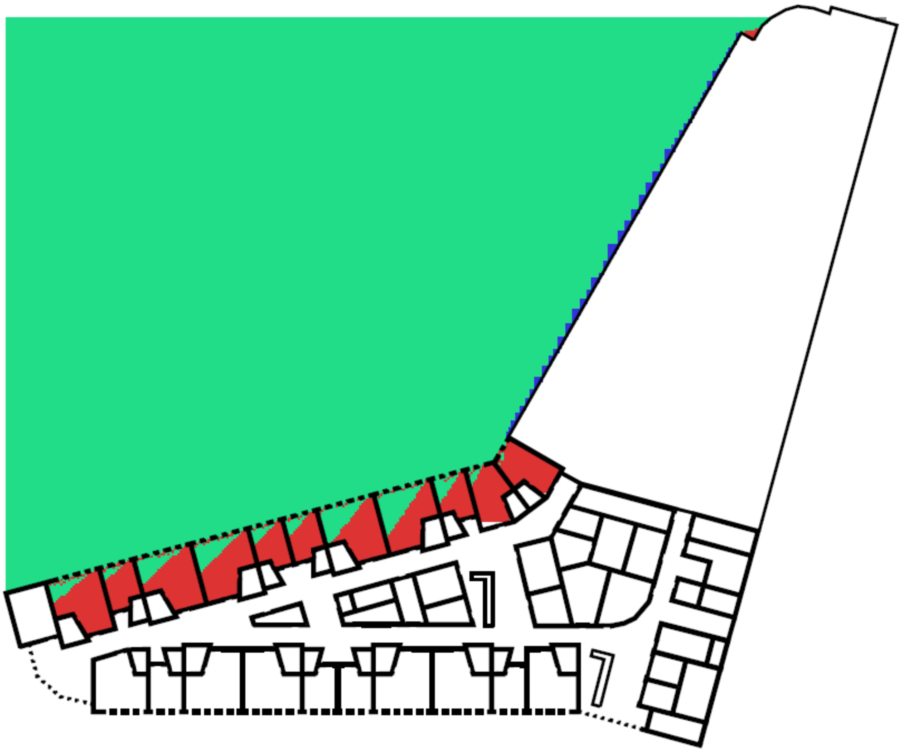

Figure 3, Visibility of outside wall from nursing department.

The wall (dark blue) is visible in the green area, the red area has no direct view of the wall.

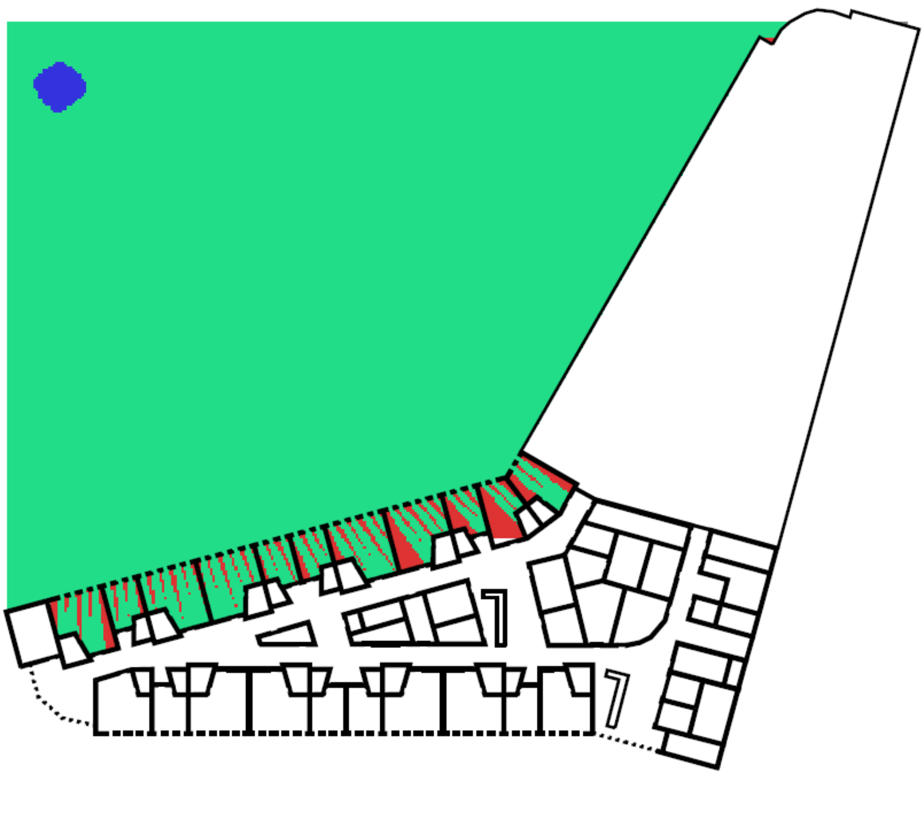

Figure 4, Visibility of a tree from patient rooms.

The position of the tree (dark blue) is visible in the green area but not in the red area.

Isovist analysis to assess daylight

Based on the floor plan and the positioning and size of the windows, it is possible to conduct different sunlight analyses. One option is a traditional sunlight study in which the direct sunlight is assessed in three-dimensional (computer) models. This is a time-consuming exercise because several timeframes in different seasons have to be utilized and even then each model only illustrates the direct sunlight visible at that specific time and on that particular day. Another option is to test a physical scale-model in a sun simulator. These studies make it possible to determine the best orientation of the building regarding patient needs, e.g. avoiding direct sunlight on patient areas. It is also possible to make an assessment of indirect sunlight in a plan, for example by regarding indirect sunlight as the visibility of the sky dome from each and every point in the building. If there is a larger part of the sky dome visible from one point in a room, the amount of indirect daylight is larger. If this is combined with a visibility analysis, from each and every point in the hospital the amount of visible indirect daylight can be determined. Based on this assessment, the amount of indirect daylight can be manipulated in the design process by changing the position and size of the windows. Figure 5 shows the visibility of daylight in the nursing department, which makes clear that all nursing rooms and almost all corridors have daylight. An exception is the area around the central reception desk where. When the doors to the nursing rooms are closed, there is no direct daylight. There are also many internal rooms with no daylight at all between the two corridors.

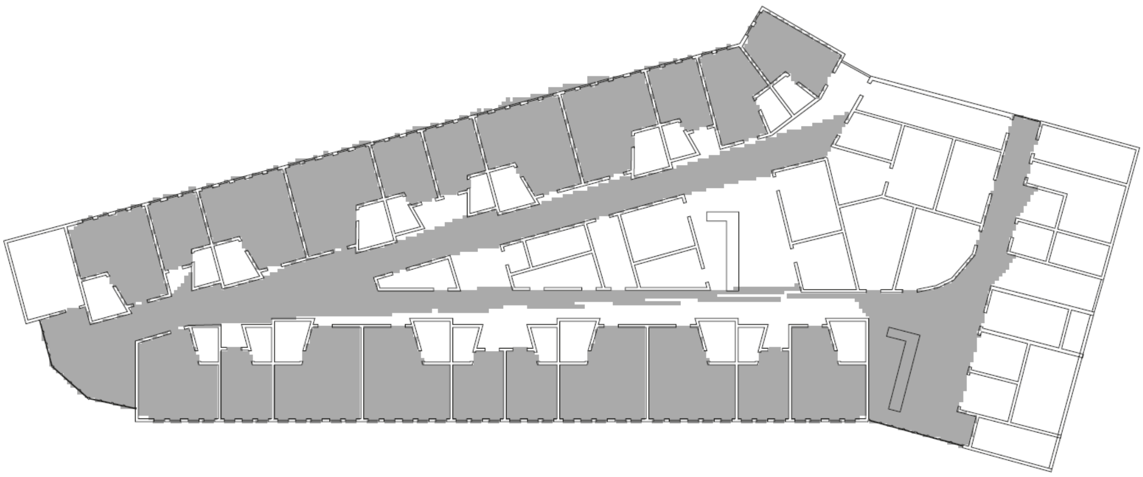

Figure 5, Visibility daylight.
This graph shows the visibility of daylight (grey area) but not the amount of daylight.

Isovist analysis to assess patient areas and reception desks

Another possibility that arises from the combination of routing analysis and visibility studies in hospitals is to assess the visibility of the patient areas from the reception desks. In this way the visibility of the main routes that are likely to be taken by patients can be combined with an isovist analysis of the reception desks. **SPACE SYNTAX SOFTWARE CAN BE USED TO DETERMINE HOW VISIBLE EACH SPOT IN THESE PATIENT AREAS IS FROM THE RECEPTION DESKS.** In this way the position and number of necessary viewpoints can be assessed in the design decision process in order to attain an optimum visibility of the waiting areas and the main patient routes through the building. Figure 6 shows the area in which reception desks are visible. Figure 7 shows the visible area for two people, one behind each reception desk. This area is much smaller, but still covers the whole entrance area of the nursing department.

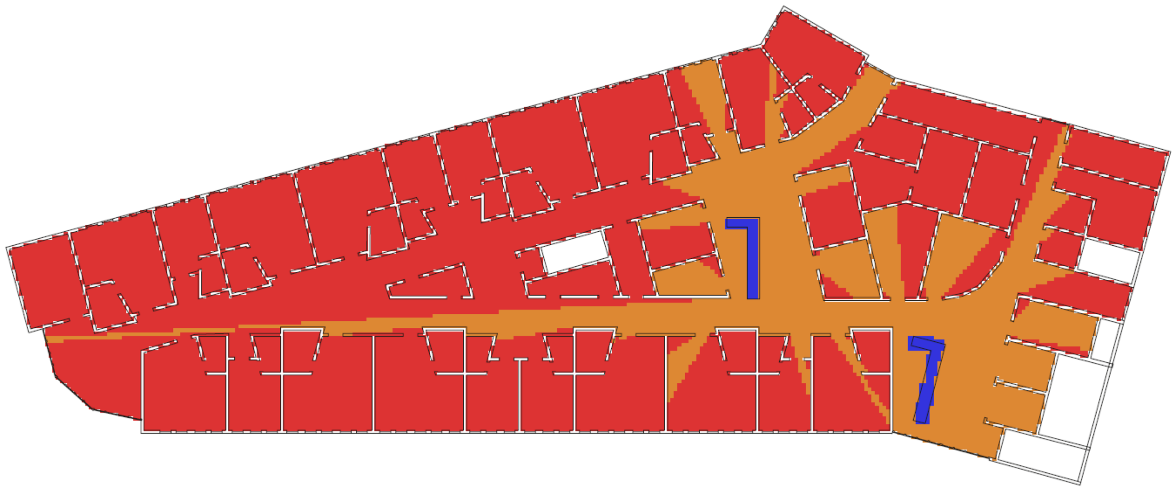

Figure 6, Visibility of reception desks.

The reception desks (dark blue) are visible in the orange area and not visible in the red area.

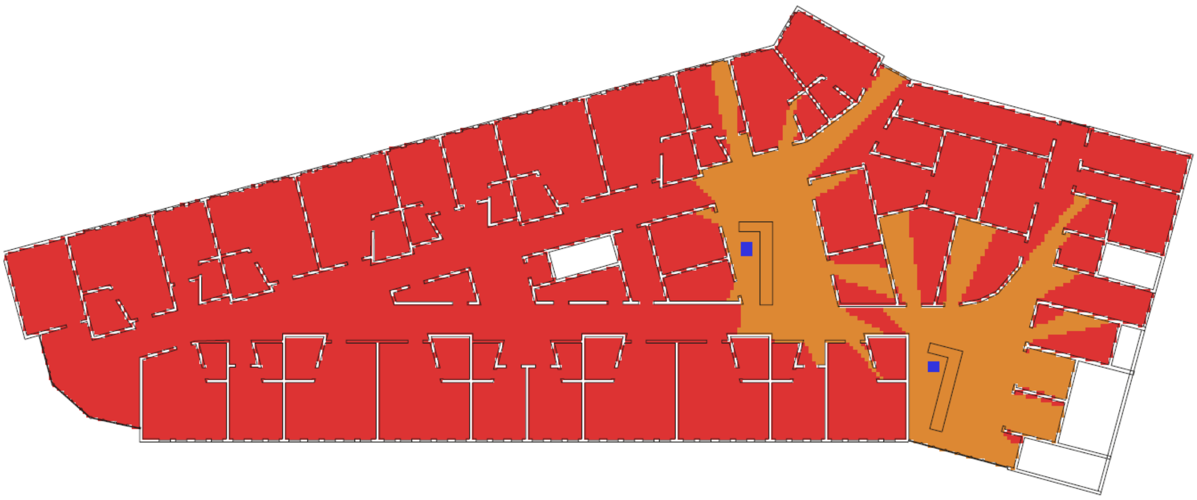

Figure 7, Visibility from reception desks.

From the two positions behind the reception desks (dark blue), the orange area is visible and the red area is not directly visible.

Convex space analysis to assess privacy and communication

A convex space is defined as a space where all points within that space can be joined to all other points without passing the boundary of the space (Hillier & Hanson, 1984). In urban analysis, other methods resulting from visibility and axial map analysis have replaced the convex space analysis because of the time-consuming work required to make a convex map and the lack of software improvements since the 1990s (Van Nes, 2011). However, due to currently available software, point depth and all lines analysis has shown to be appropriate to assess convex space in buildings. Point depth analysis makes use of a virtual grid of points and measures for each point the number of connections to other points without passing barriers like walls and columns. This analysis shows how each and every spot in the floor plan is connected to all other points in the virtual grid and as such how enclosed a space is. An all lines analysis generates as much as possible axial-lines within a floor plan.

This analysis shows the length of all lines in a color spectrum, which gives an indication of the centrality of the space along these lines. Ensuring privacy and communication between medical staff and patients is best attained by private consulting rooms and single bedrooms. For multi-person bedrooms, the availability of a sufficient number of consulting rooms nearby to speak with patients or family can be assessed in a functional floor plan analysis. In addition to privacy through single patient bedrooms and consulting rooms, privacy in the waiting areas is also an important architectural aspect of patient satisfaction (Ulrich et al., 2008). This aspect conflicts partially with the need of visibility of patient areas from the reception desks. **WAITING PATIENTS WANT TO BE SEEN FROM THE DESK BY EMPLOYEES, BUT NOT NECESSARILY BY VISITORS OR OTHER PATIENTS.** The privacy of waiting areas can be assessed using a visibility study that combines the most locally integrated routes with visibility of space from these routes and waiting areas. If this assessment is combined with an analysis of the position of the reception desks, the visibility from these desks of the main routes used by patients can also be taken into account.

Figure 8 visualizes the centrality of space and the different enclosed spaces in which a conversation can take place and makes clear that the areas around the reception desk are relatively large spaces. In Figure 9 all axial lines within the spatial configuration of the nursing department are generated by the software program. This analysis makes visible that the two corridors have the longest sight lines, and also that there are long sight lines in the patient rooms at those points where the two corridors are connected. These sight lines may indicate an intrusion of privacy because a view on a conversation is possible. Figure 10 is a visibility study of the nursing department. According to this figure, the point where the two corridors come together is the most visually integrated area in the department. Remarkably the areas around the reception desk are not the most visibly integrated spots in the spatial configuration. This indicates that the visibility of the reception desks is relatively low. A positive aspect of this is that the patient may feel less observed by others around the reception desk, possibly improving communication.

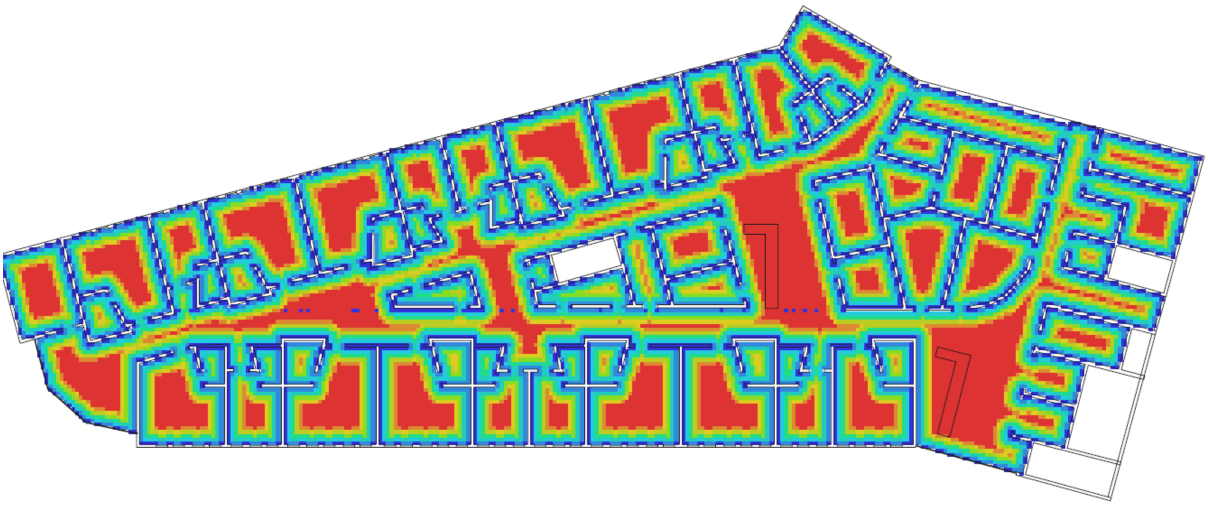

Figure 8, Centrality of space.

The color spectrum from red-orange-yellow-green-light to blue-blue-dark blue represents a continuum of high to low centrality of space and identifies the spaces for interaction.

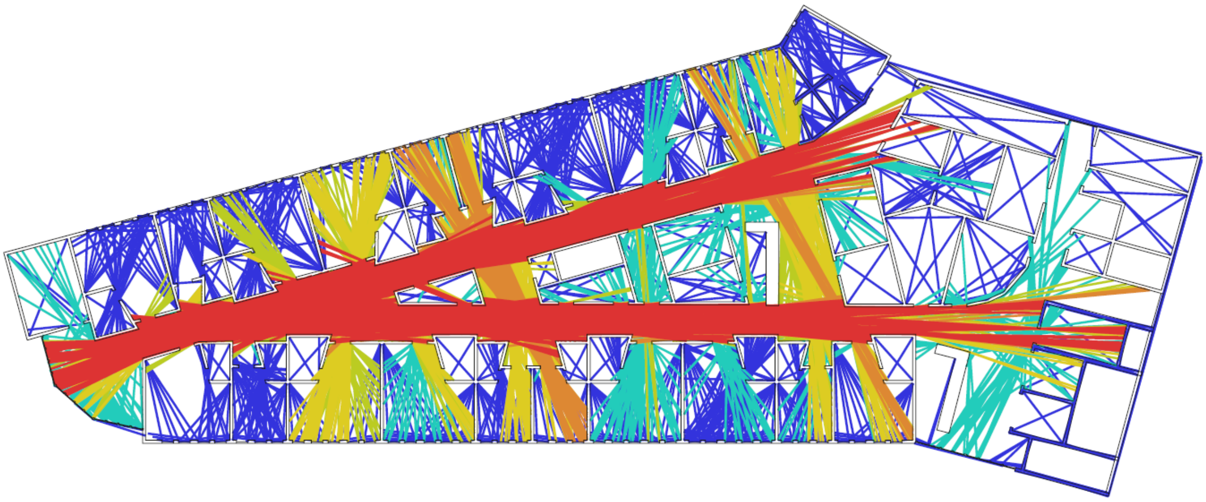

Figure 9, All lines axial map.

The color spectrum from red-orange-yellow-green-light to blue-blue-dark blue represents the length of the sightlines (from long to short) and shows which space is most visible.

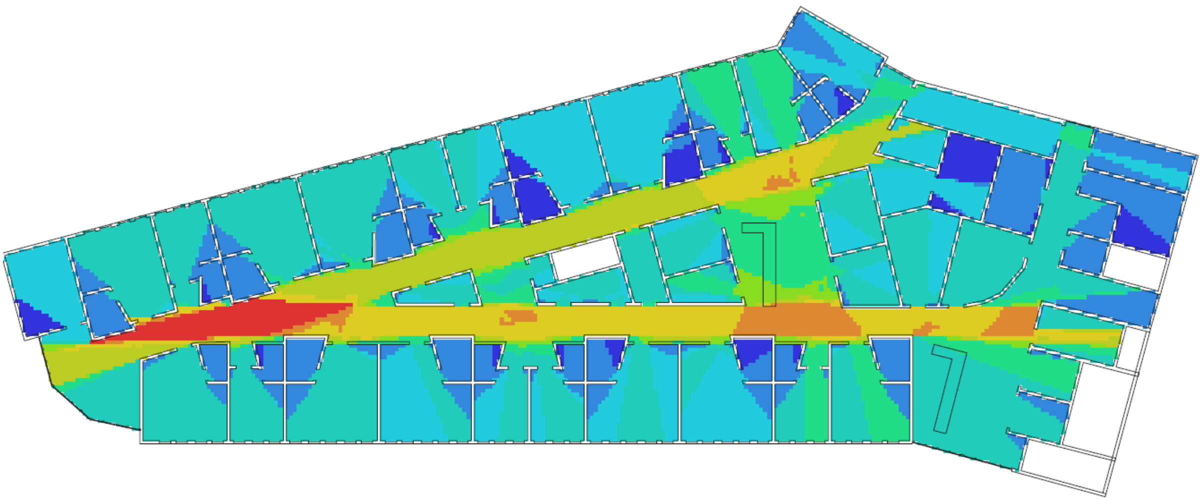

Figure 10, Visual integration.

By using a color spectrum from red-orange-yellow-green-light to blue-blue-dark the most visible area (red) and less visible area (dark blue) is shown.

Agent Based Modelling to assess noise reduction

Agent Based Modelling (ABM) is a technique to simulate movement within a floor plan by using agents as self-deciding entities within a computer model. These agents move as virtual persons through the floor plan in finding their way based on programmed decisions. The directions these agents choose can be assigned randomly, or by following given rules such as the direction of the longest sight line or the most integrated route. Agent based modelling can show what are likely to be the most used areas in the layout. **ALTHOUGH THE AMOUNT OF NOISE IS NOT PREDICTABLE IN A FLOOR PLAN, IT IS POSSIBLE TO MAKE AN ASSESSMENT THAT INDICATES THE QUIETER AND LIVELIER SPOTS.**

An axial map analysis can show the most locally integrated routes, which gives an indication of the probability that people will use those routes. After that, a point depth analysis can be conducted to show how visible the main routes are from each and every point in the hospital plan. If one spot has strong visual contact with a high locally integrated route, this spot is likely to be more lively than a spot that has less (or no) visual contact with a lower locally integrated route. The level of local integration can also be made visible by agent based modelling. A visibility assessment can be conducted to define the extent to which agents are visible from each and every spot as an indication of higher or lower noise level. In this analysis, the agents are perceived as moving noise factor and the visibility of these agents is used as an indicator of the amount of noise on that spot. This instrument is also applicable in staff areas for reducing noise levels in work stations in an open office concept. Figure 11 and Figure 12 are both agent based models from the nursing ward. Figure 11 shows the internal circulation that is to be expected due to the configuration of the nursing ward. Figure 12 shows how these agents spread from the elevator as the point of entrance. The combination of both figures shows that the lower corridor is used much more often than the upper corridor and that the area between the reception desks is also used by many agents. This leads to the assumption that some bedrooms are much less quiet than other bedrooms in the department, based on the view of the movement of people through the hospital.

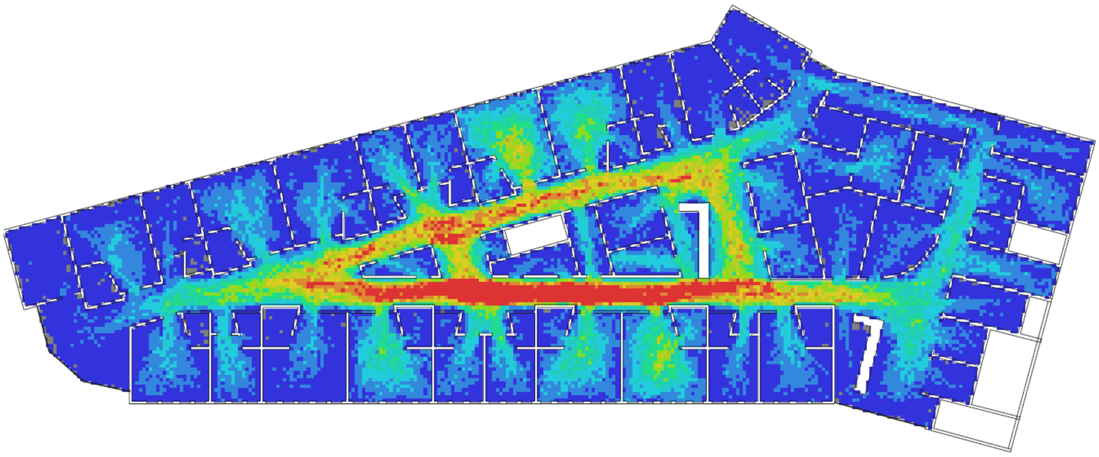

Figure 11, Agent based modelling of internal circulation.

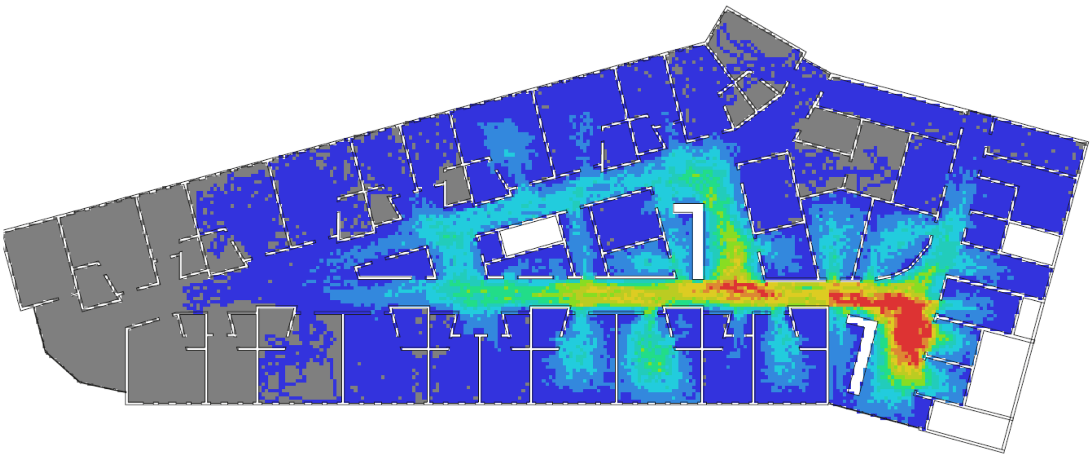

Figure 12, Agent based modelling of circulation from entrance.

The color spectrum from red-orange-yellow-green-light to blue-blue-dark blue-grey represents the number of passing agents as an indication of the noise that is related to the circulation of people in the composition.

CONCLUDING REMARKS

Only added values of real estate that are incorporated into the final design contribute to achieving the pre-set objectives. So the translation of pre-set objectives regarding the accommodation into the architectural design is a crucial step in achieving added value by real estate (Van der Zwart, 2014). In addition to defining these objectives in advance, value adding management of hospital real estate also requires to measure these values in the design and use phase. This assessment can be conducted either ex-ante (before the construction phase), by an assessment of the architectural design, or ex-post (after completion of the building), by a Post Occupancy Evaluation (POE). Analysis of plans by using drawing techniques and computer modelling tools from architecture and urban design makes it possible to visualize various aspects of use-value. This enables decision-makers to make value adding management of real estate to become part of the design process. As such, design-assessment also sheds a new light on Evidence Based Design (EBD). Whereas traditional EBD i.e. the application of the best available scientific evidence in the design process is mainly based on Post-Occupancy Evaluations of buildings-in-use and ex ante testing of full-scale mock-ups, Design-assessment by using drawing techniques is a way to test in advance, before the building is built, to what extent organizational objectives and the aimed performance are supported by the architectural design plans. This enables to incorporate usability issues and perceptual qualities in the discussion between the designer, the client and the end users during the design process. Design-assessment by using drawing techniques adopted from space syntax creates new opportunities to involve the user in the design process and for "user oriented design". In addition to exploring design alternatives, these techniques can also be applied to optimize the current architectural design. The test of the methods in a case study showed that **THE AVAILABLE SOFTWARE OF SPACE SYNTAX HAS DEVELOPED TO A POINT WHERE IT CAN BE APPLIED BY ARCHITECTS IN THE DESIGN PROCESS.** The appearance and usability of the software is comparable to common drawing programs like Autocad and Vectorworks. The basic steps are easy to explain to someone who is used to work with Computer Aided Design (CAD).

An interesting topic for further exploration is the use of these techniques in combination with Building Information Management (BIM) in the design, construction and building-in-use phase (Andrews, Senick, & Wener, 2012). BIM aspires to digitally represent the physical and functional features that are needed to develop and document building designs. Today, BIM applications support walk-through visualizations, heating-ventilating-air-conditioning system design, energy performance estimation, lighting design and the assessment of safety and security issues such as evacuation (Preiser & Schramm, 2012). The drawings and graphs can provide a thorough insight into the consequences of the spatial design for the end user. Although patient satisfaction is perceived as one of the most important values by hospital CEOs and real estate project managers (Van der Zwart, 2014), assessing other added values is also important in the design phase, e.g. flexibility or productivity. Designing is balancing between and synthesizing of different and sometimes conflicting values. As a consequence, all possible values should be assessed in the design phase. The aim of this paper was to explore analytical drawing techniques as means to assess the attainment of pre-set objectives in the design phase of a hospital. Therefore this paper explored the usability of Space Syntax and applied the theory and methods from literature on a floor plan analysis of one nursing department. A consequence of this explorative approach is that in this paper only one example of added value is assessed in just one case study in which the focus was also only on the floor plan analysis. As such, this paper presented an analytical approach resulting from the theory on space syntax. The case study is used as an illustration of this approach but is not yet to be regarded as hard evidence, because the analyses are indicative and the findings have to be validated empirically ex post as well. Therefore, it is recommended to test the findings of the design assessment by a Post-Occupancy Evaluation of the building-in-use and to conduct similar studies in other hospitals, as a means to build a body of knowledge for user-oriented design and management of hospital buildings.

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PRACTICAL IMPLICATIONS

- Design-assessment is a way to test in advance, before the building is built, to what extent organisational objectives and the aimed performance are supported by the architectural design plans.
- Re-drawing techniques based on Space Syntax methods and reduction, démontage and addition show different layers of information and as such can help to visualize various aspects of use value.
- Pre-Occupancy evaluation using re-drawing techniques may support the incorporation of usability issues and perceptual qualities in discussions between the designer, the client and the end users.
- The findings from a design assessment regarding view on nature; way-finding, daylight, visibility of patient areas from reception desks, privacy and communication between medical staff and patients, and noise reduction are valuable input to support Evidence Based Design (EBD).