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# Trade-offs in Evidence Based Design: 'the Patient Door Debate'

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**Abstract.** The door between the semi-public corridor and the single-occupancy patient room of a newly built University Medical Centre in the Netherlands has been heavily debated during its Evidence Based Design (EBD) and experience-informed design. It was also heavily debated since the wards came into use in 2018. It is well known that, regarding door design, a trade-off has to be made between aspects such as privacy, visibility, and safety. This makes our case study exemplary for the trade-offs to be made in EBD practice. This study traces back to how the design decisions for the door, dating from 2011, were made. Safety, privacy, control, and support for the social and emotional wellbeing of patients, relatives, and staff were the aim, but this is not experienced as such by all concerned. This case study evaluation highlights the tension between EBD principles and everyday practice, where the interplay between 'bricks, bytes, and behavior' has to be considered, and every consciously debated design solution might bring new and unforeseen challenges elsewhere. Our practice-based research combines the analysis of documentation on the design decision-making process with evaluation interviews with nurse managers in 2019. Our findings on 'the (Dutch) patient door debate' can contribute to awareness of trade-offs to be made in health facility design, complemented with supportive IT systems and efficient and effective staff workflows. It can enhance the understanding of the many aspects that need to come into consideration during design dialogues with experts and end-users.

**Keywords.** single-occupancy rooms, safety, privacy, patient wellbeing, door design, EBD, trade-offs

## 1. Introduction

Often, relocation to a new healthcare facility comes with service transformation and accompanying technical innovation. Relocation to a hospital with 100% single inpatient rooms is such a service transformation [1]. The impact of transformational change alongside a hospital design and construction project is still an under-researched area, although it is clear that end-user experience is affected upon relocation [2-5]. Moving to a new facility comes with a multitude of smaller and larger changes, which makes it difficult to examine the success of the built environment, let alone one element of it,

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independent of its context. The end-user experience is made up of the building itself, the provision of (IT) services and smooth-running processes supporting their work, and their personal ability to adapt to the changes involved [6]. This, in our opinion, implies one has to look at the interplay between the 'bricks, bytes, and behavior' associated with the new built environment when evaluating new hospital facilities [7].

Hospital construction and transformation projects are well known for their complexity because of their often pluralistic nature and the involvement of multiple stakeholders with potentially divergent perspectives influencing decision-making [1, 8-10]. Stakeholders involved in the design phase, representing clinical and non-clinical experts and end-users, may have different priorities regarding focus on patient safety (e.g., infection prevention, prevention of falls) than nurses experiencing the new ward environment upon relocation (e.g., easy monitoring). At the early stages of hospital redevelopment, staff experience both positive and negative expectations that are dependent upon their level of personal understanding and awareness of the change to come [4]. Stakeholder engagement is an important mechanism in the subsequent stages of a project to align project goals [11]. This study contributes to the Evidence Based Design (EBD) knowledge by examining the relationship between decision-making in the design of the built environment and staff and patient-reported health-related outcomes [12]. In this paper, we address the following research question: how can patient well-being and safety be best served in a multi-facetted design solution?

The design element of focus in this study is the door between the semi-public corridor and the single-occupancy patient room in a University Medical Centre (UMC) in the Netherlands. This element was chosen because of the established dialectic between autonomy (e.g., patient control over privacy) and security (physical safety (e.g., infection prevention and control) and peace of mind (e.g., staff presence)), where patient visibility is considered a moderating factor [13]. In addition, in Post Occupancy Evaluations (POE) researchers often find a gap between intentions and practice during evaluations with end-users [14].

In this case study we were in a unique position to reconstruct stakeholder priorities and decision-making processes. This reconstruction starts with front-end planning and the EBD and evidence-informed design processes and ends with 'New Ways of Working' (NWW) and the POE. Additionally, the impact of COVID-19 use and repurposing of general wards to so-called 'surge-ICUs' is analyzed with respect to the physical barrier of the door to the patient room. Finally, the debated trade-offs at this particular UMC (our case study) are compared with wider design practice in the Netherlands for recently built or renovated hospitals. The aim of this research is to get a better understanding of the many aspects that must be considered during design dialogues with experts and end-users. This can then raise awareness of the vital moments where trade-offs between patient well-being, patient safety, and staff efficiency and effectiveness are being discussed, as well as the interplay of the built environment (bricks) with IT services (bytes) and actual human behavior. The enhanced understanding of perceived performance and appreciation of a particular design solution can then be translated into choices in stakeholder engagement in design approaches and decision-making processes.

## 2. Framework

### *2.1. Evidence Based Design (EBD)*

EBD is defined as the process of basing decisions about the built environment on credible research to achieve the best possible outcomes. Design decisions are linked with outcomes at every stage of the EBD process, and as a result, evaluating the impact of design decisions on outcomes is a critical component of EBD [15]. Ideally, EBD should support the Quadruple Aim for Healthcare (introduced by the Institute for Healthcare Improvement (IHI) in 2017) by achieving better outcomes, improved patient experience, improved practitioner experience at lower costs. EBD research is a growing field, with often the patient-centeredness of health facility design at its core.

An extensive Dutch study divides the vast available EBD knowledge into three design aims: (1) patient safety; (2) patient well-being; and (3) efficiency and effectiveness of staff [16]. Patient safety is a clear driver for design decisions focusing on infection prevention and the application of single-occupancy rooms [17, 18]. Patient well-being is associated with the reduction of stress and other elements of what is often called 'a healing environment' [19]. Efficiency and effectiveness of staff have become more important over the years due to staff shortages, which corresponds with the addition of the IHI compared to their previous Triple Aim strategy.

In the US context, the element of lower costs has been investigated using the Fable Hospital metaphor [20, 21]. EBD-guided hospital designs might require higher capital costs, but these additional investments are recouped by lower hospital running costs, e.g., due to fewer Hospital-Acquired Infections (HAI) and reduced staff turnover. However, in practice, it is still difficult to adopt a life cycle costing approach for hospital design and construction projects, as decision-making on capital funding is often controlled outside the hospital organization itself.

And even if a hospital were to adopt EBD practices, as advocated in healthcare design literature, this does not automatically lead to a descriptive design solution. Architects are known to express reservations about the 'art' of architecture being curtailed by EBD-guided design [22, 23]. This concern, however, is addressed by Roger Ulrich, one of the founding fathers of the EBD movement: "*Perhaps the most difficult aspect of the evidence based design process is to take the evidence and understand it, critically interpret it, and then analyze the relevance for the unique context of each project. (…) The same evidence can help designers create quite different approaches for addressing similar issues or objectives.*" [24]. Similarly, the design context plays a role: the same evidence may lead to different approaches at different scale levels, such as the ward environment or the single-occupancy patient room [16]. This understanding of the evidence relates to the important notion that the same concepts might be operationalized in different ways between medical and technological sciences [25]. One of the resulting challenges in hospital design is to bring these worlds together through the operationalization of concepts from different perspectives. Indeed, standardization of terminology on architectural variables and health outcomes by creating a common language across studies and practitioners is seen as a way forward in EBD research [26].

### *2.2. Bricks, Bytes, and Behavior*

The concept of bricks, bytes, and behavior originates from introducing NWW in an office environment, where the use of ICT (bytes) is seen as an important enabler for a more

flexible use of the work environment (bricks), also leading to new relationships between employees and management (behavior) [27]. During the recent COVID-19 pandemic, this IT-enabled flexibility has helped many health care workers (HCWs) continue their work at home or make a switch to video consultations, finally making 'digital first' a common practice [28]. Ideally, all three elements (bricks, bytes, and behavior) are balanced and continually optimized throughout all project phases. Making a shift to 100% single-occupancy inpatient rooms can be seen as an illustration of this transformative change in bricks, bytes, and behavior. It is known that single occupancy rooms (bricks) present a number of challenges to HCW, such as different relationships with co-workers and patients (behavior), changed perceptions of patient visibility, increased by-the-bed patient care interactions, altered resource allocation, and the need for different communication techniques (bytes) [7, 29].

In health facility design, HCW behavior is often not well addressed. To some extent, this might be so because the dominant discourse in EBD practice emphasizes the importance of a healing environment and highlights patient-centeredness as a common ground in hospital design [30, 31]. Alternatively, it may also reflect that many professional stakeholders in design teams have a background in technology and engineering and are trained to consider behavior as the result of a rational process that can be shaped by 'bricks' and 'bytes'. Especially in healthcare, the complexity and related uncertainty for individual actors in transformative change comes with 'messiness' and room must be allowed for adaptive actions alongside intentional approaches [32]. To reach a state of 'mental ownership' of a new ward configuration with 100% single-occupancy rooms, HCWs may want to adapt their work environment to better suit their needs.

### *2.3. Stakeholder Engagement*

The 'bricks, bytes, and behavior' concept already mentioned the difficulty of operationalizing HCWs' workflows and their behavior within a certain setting. HCW (as end-users) are important stakeholders that need to be engaged in the design process. Various studies have discussed the relationship between user involvement, design quality, and project success [33, 34]. In a case study of two Finnish hospitals, Reijula found that hospitals that involved end-users in the decision-making process and provided them with representation in the core design team enjoyed enhanced commitment, improved work efficiency, and acceptance of design solutions. This end-user engagement and the opportunity to clarify the trade-offs involved in the decision-making processes encountered were found to be beneficial for the atmosphere and staff satisfaction in these hospitals [35]. This example shows that the engagement of stakeholders, such as end-users, but also experts like occupational health professionals or hospital hygienists, is crucial in planning and design projects [7]. However, while architects and designers specialize in problem-solving by design, they are not always fully versed in studying the interactions of work tasks, flow, and functions of multiple subsystems of end-users and experts. Especially in the early phases of design, functional programs of requirements or room data sheets do not capture the complexity of the system. Project managers, designers, and engineers, all remote from the clinical front line, base solutions on work as imagined rather than on work as performed [36].

## 3. Methods

This retrospective qualitative case study used mixed methods. It built on the work of Maben et al. in evaluating patient and staff experiences of 100% single-occupancy patient rooms in the UK and later in Australia [37, 38]. Additionally, we had access to all project documentation on design and decision-making processes. Combining these sources helped reconstruct stakeholder priorities in the different phases of the project and showed which trade-offs were considered (or ignored).

### *3.1. Project Documentation*

A limited review of existing literature was performed to introduce the theories used. To study the trade-offs in our case study, we were able to reconstruct decision-making processes on the door design by analyzing project documentation. Examples of project documentation are minutes of meetings between the design team and end-users, minutes of meetings with project stakeholders such as the Client Board and the Steering Committee, as well as the program of requirements, preliminary and final design drawings, and remarks made on the full-scale mock-up tested by stakeholders and the public in 2007. For the phase of functional programming and design, approximately 1000 versions of documents are available in the digital archive of the hospital's project management organization. As a former member of the project's management team, the first author had access to these documents. The project documentation also grounded the design on the anticipated work processes and envisioned IT support.

Based on the project documentation, it is noteworthy to mention that the architectural firm that was commissioned to do the design of the new ward environment was already onboard at the stage of the conceptual development of the project and the single-occupancy wards. Likewise, the UMC was able to appoint in-house experts to develop more qualitative requirements for the project and guide their use during successive phases of planning, design, construction, and commissioning.

### *3.2. Evaluation Interviews (2019)*

As part of a wider scientific evaluation program focusing on the new ward concept, its perceived outcomes for patients and staff, and the presence of microorganisms in patient rooms, evaluation interviews with ward managers and other hospital staff were conducted. In a POE of the ward environment, the first author and the lead architect for this design conducted semi-structured interviews. The semi-structured interview protocol was derived from Maben's evaluation interviews [38]. The interviews focused on the functionality of the ward and the new work processes as perceived by the ward managers some 9-18 months after relocation. The seven ward managers that were interviewed each have a responsibility for 50-100 patient rooms, out of a total of 522 patient rooms. Of the seven ward managers five are females and two are males. At the time of the interview, all ward managers were over 40 years of age, two of them were over 60 years of age, and all have a background in nursing. Some of them had a long history with the project, and all had been part of the NWW project the hospital started four years prior to relocation. Interviews were audiotaped and transcribed.

### *3.3. Analysis*

First, in our analysis, we established timelines for the development of the design based on the project documentation available. In these timelines, it becomes clear that the design of the door is an architectural variable that is not prominent in the early phases of operationalizing the concepts coming with the 100% single-occupancy room decision. However, the physical barrier between the corridor and patient room was debated in later phases.

In the interviews, the 'door' was a design element that was often mentioned. Interviews were transcribed and analyzed using ATLAS.ti, and for this study, 'door' was used as the code to find all the remarks made by the ward managers. This study is part of a larger study for which Institutional Review Board (IRB) clearance was obtained.

Our research team combines the perspectives of environmental psychology, project management in design and construction projects, and architecture (practice and research). Findings were discussed within our team, and the architect added the wider practice in the Netherlands to our findings.

## 4. Findings

### *4.1. Design Decisions*

In reconstructing design decisions as part of the concept of single-occupancy patient rooms, enhanced patient safety and enhanced patient well-being (privacy and stress reduction) are both part of the narrative, as mentioned in Table 1.

**Table 1.** Timeline summarizing development of the single-occupancy patient room concept.

| Period | Ward development |
|---|---|
| 1998-2000 | Conceptual model: (1) reduction of number of beds thus optimizing use (flexibility through standardization); (2) higher acuity and increased care needs during shorter stay; (3) enhanced patient safety (infections prevention and control, reduction of (medication) errors); and (4) enhanced patient experience (privacy, stress reduction). Results in model of care with 100% single occupancy rooms in the inpatient wards. This conceptual model is approved by internal stakeholders, including patient representatives. In the governmental review of the conceptual model questions are raised regarding the evidence in favor of single occupancy rooms. |
| 2000-2007 | Conceptual model is operationalized with stakeholders (patients, experts and clinical and nursing staff); concerns are raised regarding patient loneliness and safety, walking distances for staff and associated costs. From the viewpoint of patient centeredness the advantages are seen in allowing demand-driven care, giving the patient more autonomy and control, providing privacy, noise reduction and improved sleep, more 'room' for direct patient-related activities at the bed-site and enhanced physician-patient communication. With this input, using EBD findings and their own tacit knowledge the design team develops a template for 4 types of patient rooms and supporting spaces. All room types can be characterized as having an inboard en-suite and large windows over the full length of the façade. A full-scale mock-up of the patient room is used to assess the choices made. |
| 2008-2012 | The concept design is further developed in the context of a functional program for the wards, anticipating process redesign. Digitalization seems promising in offering wireless technology for nurse call, digital room information display, etcetera. The design of the wards is finalized. |
| 2014-2018 | The NWW-program is established to redesign and implement new and standardized ward process redesign, including support processes such as medication, ward logistics and food services. |

Patient safety is highly associated with infection prevention and control, while well-being would be served by providing the patient with more control over his own space, acoustic privacy, and room for social support. The perspective at the time was very patient-centered, although a 'healing environment' in this hospital's narrative includes staff well-being. And all further decision-making has to deal with the priorities set: 'safety first' and 'healing is leading'. The safety angle again and again highlights the emphasis on Infection Prevention and Control (IPC), which is dominant in many trade-offs to be discussed at a later stage. The timeline also shows that nurse workflows and IT-supported measures to overcome disadvantages with the single-occupancy rooms and impaired patient visibility feature are prominent in the debate.

The timeline in Table 2 summarizes the development of the door itself. The discussion about the door is kicked off when an alternative is needed for the first suggestion of the design team, the semi-transparent glass door depicted in Figure 1. The glass makes the door very heavy to handle. This would require automation of the opening and closing of the door, which is considered to be very costly. Besides, there are concerns about privacy and dignity and making the patient room dark enough at night, so as not to hinder patient sleep. In the subsequent discussions, patient-centeredness is the dominant perspective: it is seen to be important that the patient is in control of having a connection to the world outside his room or keeping that world with all its stimuli outside and enjoying complete privacy. When this free choice is compromised for patient or staff safety reasons, an Airborne Infection Isolation Room (AIIR) is provided, with glass in the door (with blinds that can be controlled from the inside) offering this connection to the world outside.

**Table 2.** Timeline summarizing development of the door.

| Period | Door development |
|---|---|
| 2007 | A full-scale mock-up of the 2007 design for the patient room, as suggested by the design team, is assessed by hospital staff, patient representatives and patients and the general public (during an open day)<br>- because of the transparency of the glass door, the issue of a privacy curtain is raised; however, IPC-experts are against the use of a privacy curtain, as these can be a source of contamination when handled by different staff members, and this curtain lacks a clear 'owner' where its (frequent) washing is concerned. This results in a recommendation to use a (more) solid door.<br>- a mirror is placed on the wall at the entrance of the room to enhance visibility of the patients head through open door. |
| 2007-2011 | Part of the privacy, autonomy & control ambitions in enhancing the patient experience is providing a choice whether a patient wants to be in touch with the world outside. In standard rooms this implies having the door open. However, IPC experts warn that all rooms are considered to be isolation rooms when it comes to contact or droplet isolation, and doors will have to be kept closed. The design team, however, is more focused on the situation when the door has to be kept closed to protect the patient or his environment from airborne transmissible infections: a glass inner door and glass with blinds in the outer door of the AIIR are provided to allow the patient visual contact with that 'outer world'. |
| 2012 | The ward design is finalized with a solid wooden door for the standard room, and the two doors described above for the AIIRs. IPC experts again argue that for safety reasons that many doors of the standard rooms will need to be kept closed as well, and recommend a glass window with blinds in these doors as well, to prevent the doors from standing open to allow the patients visual connection to the ward, or staff entering a room without wearing PPE. However, after prolonged deliberations it is decided not to add a window in the door: this would require blinds or a curtain to provide privacy in the room and to properly dim the room at night, and would add to the investment costs. The final argument for internal stakeholders at this stage is, also with patient safety in mind, that monitoring of a patient's vitals, settings of IV-systems, etcetera, has to be done at the bed-site, and cannot be done from the corridor. |

### *4.2. Construction and Implementation*

During construction, one patient room was finished and tested before the other 521 were built. This 'mock-up' room, however, was an example of an AIIR. Although thoroughly tested by internal stakeholders, no notice was made of the fact that the mirror had not been placed where it had been designed at the entrance of the room. This might have been due to the fact that in the demarcation with the contractor, this mirror was not included and was believed to be added at a later stage as part of the commissioning project. Reconstruction of decision-making within the budget allocated for commissioning was not possible, and it appears that the placement of this mirror was not quality-checked by the project team. However, based on this 'mock-up', it was decided at this late stage and at extra costs that the outer doors of AIIRs and the so-called XL-rooms (rooms at the corners of the building that gained some extra width due to the positioning of the facade) would be automated, as they were still quite heavy to handle. The IPC experts had requested automated doors in all AIIRs, to enforce an interlock situation in the anteroom. However, and again to save costs, this was not implemented in all AIIRs.

**Figure 1.** the semi-transparent doors in the mock-up of 2007 (EGM architects).

In 2015, the NWW program started in order to prepare staff for the newly built environment. Part of the preparation for the implementation of the new (standardized) work processes was to perform a fit-gap analysis. In workshop-like settings, staff discussed how the new ward environment would influence their practices and what issues would need to be addressed. The solid door was an architectural variable that was discussed during these meetings. IPC experts warned that many doors would need to be kept closed for nursing patients with a contact or droplet isolation indication. Some departments discussed the solid door in their risk assessment of the new environment and established work practices or workarounds.

Soon after relocation to the new hospital, complaints about the solid door were expressed to the Sounding Board guiding the relocation project. Because of the acoustic

quality of the door, patients could not hear staff or visitors knocking before entering. Nor could they hear the patient's answer. This meant people walked in on patients being examined or assisted in their beds, compromising dignity. The proposed solution was to implement a curtain behind the door, so this could be closed to shield the patient from view when someone would enter the room. However, as IPC experts had already ruled against this solution in 2007, this was not considered to be an feasible option. An alternative was found in a hotel-style door hanger, indicating whether patients could be disturbed. From the perspective of staff itself, a major concern was not being able to see where a colleague was busy and might need assistance while working in a room behind a closed door. It had been suggested that the patient room display might be programmed to indicate the presence of a caregiver in the room, but this IT-supporting feature was not available at the time. Although these (and other) concerns were voiced in the early days after relocation, no changes were made to the doors.

### *4.3. Evaluation*

Given the early concerns about the door after relocation, the door was one of the subjects assessed during the evaluation interviews with ward managers. The quotes have been summarized in Table 3 and have been related to the concepts of safety and visibility, privacy and dignity, autonomy, behavior and workflow, and bytes (indicating IT-supported systems). The nursing workflows were found to be complex, to differentiate between specific wards, and thus to diverge from the standard advocated in the NWW project.

Concerns from an oncology ward on limited possibilities for visual monitoring patients were not heard from a cardiology ward, based on the availability of continuous monitoring data (telemetry). The argument for close supervision at the bedside was found to discard the need expressed by nurses for more peripheral visibility from the corridor as an indication of the patient's well-being or the localization of a colleague. Meanwhile, we also found that many patients liked to have their door closed for visual and acoustic privacy, especially at night. Moreover, contact and droplet isolation protocols curbed the patient's control over whether the door was open or closed. For contact and droplet isolation an AIIR is not needed, but enforcing the door to stay closed withholds the connection to the world outside for these patients. Although the IPC experts had predicted this practice, the frequency of this situation was not properly assessed by the design team in its final decision making (where costs became an increasingly dominant factor).

Table 3 illustrates that in the quotes from the ward managers, all the elements of 'bricks, bytes, and behavior' are addressed. The intent to apply EBD knowledge to the design has highlighted trade-offs. These trade-offs indicate that most advantages (e.g., improvement in infection control, increased acoustic and visual privacy) may come at the cost of disadvantages to staff efficiency and effectiveness (such as reduced peripheral vision of patient well-being or the presence of a colleague). The medical paradigm of infection control and cost control by the project management team seem to have been prioritized over nurses' easy workflows. The perspective of patient-centeredness during the design phase is recognized by staff in the new ward environment, but it has also led to unforeseen challenges for staff.

**Table 3.** Quotes from the ward managers related to concepts.

| Concepts | Quotes from the interview transcripts | # mentioned |
|---|---|---|
| **Safety & visibility** | | |
| | No problems encountered by nurses, as telemetry is available in all rooms | 1 |
| | The feeling of unsafety about (a possible patient hiding behind a) closed door was mediated by risk-assessment prior to relocation | 1 |
| | You really have to go inside, to see if the patient is okay | 3 |
| | Many doors are kept open for monitoring purposes | 1 |
| **Privacy & dignity** | | |
| | No indication light available to warn when patient is receiving care or does not want to be disturbed | 2 |
| | A curtain behind the door is not allowed for IPC reasons | 2 |
| | Often patients prefer the door closed, especially at night | 2 |
| | Often patients prefer the door closed, especially with visitors present | 1 |
| | When blinds in an AIIR are not properly closed in the outer door, patients opposite can have a view of what is happening in this room | 1 |
| | With the door open, (vulnerable) patients are very visible | 1 |
| | Visitors wrongly walked in on a dead patient | 1 |
| **Autonomy** | | |
| | The choice lies with the patient whether contact with the outside world is preferred | 2 |
| | Bedridden patients have to rely on others to open or close the door | 1 |
| **Behavior & Workflow** | | |
| | People just walk in; knock and answer are often not heard through solid door (good acoustics) | 1 |
| | Vulnerable patients in palliative care require the door to be closed, but frequent entry is necessary | 1 |
| | With (contact and droplet )isolation protocols it is hard to keep the door closed (this is easier in the AIIRs with glass in the door) | 2 |
| | No indication where a colleague is present, no indication light available | 2 |
| **Bytes** | | |
| | Telemetry in all rooms solves the anxiety of staff | 1 |
| | The proposed workflow to change the color of the digital room information display (to indicate colleague is helping patient or patient does not want to be disturbed) is too complicated | 1 |

### *4.4. Evolution Due to COVID-19 Practice*

The pandemic has acted as a stress test for the new wards. Research in the case study hospital showed that the single-occupancy rooms offered an advantage in terms of infection control and creating safe working environment for staff [39]. However, hands-free (or gesturing) communication between staff in the room of an infected patient, wearing full PPE, and colleagues in the corridor (without wearing PPE), was hampered by the solid door. Particularly, this was reported as a problem in the surge ICU, which had been a standard nursing ward, although with the provision for telemetric monitoring. While there were cameras installed in these room and a baby phone had been set up to monitor sounds from the patients outside the room, technology could not meet this hands-free communication need from staff. Between the first and second waves of the pandemic (in the summer of 2000), some 50 doors were altered by adding a window with shades in the door. This alteration in the surge ICU prepared for COVID-19 patients is in line with the intended practice in AIIR in the nursing wards. Also, this window in the formerly solid door is the solution that had already been advocated by IPC experts and

staff prior and post relocation. Now these rooms are repurposed for standard (medium care) use, nursing workflows seem to be better accommodated.

Some wards with the standard single-occupancy rooms were dedicated for COVID-19 care: patients suspected of or confirmed in carrying the virus. Here, staff (and visitors) would only wear PPE while entering the room. On these COVID-19 wards additional continuous monitoring was introduced, enhancing patient safety and staff comfort with their patient laying behind a solid and closed door. This comfort of continuous monitoring echoes our POE-findings with telemetry on the cardiology and cardiothoracic wards.

### *4.5. Wider Practice in the Netherlands*

In the case study described so far, we were able to reconstruct decision-making in a design and construction project for a newly built hospital. In ward renovation projects, design variables may already be restricted by existing floorplans (e.g., the decision to have inboard or outboard en-suites, or en-suites between rooms, that require additional length of the façade). In newly built facilities, there might be more room to translate qualitative concepts with EBD knowledge into the design. However, many choices related to trade-offs found in our case study are already laid down in the program of requirements. In the Dutch hospital design practice, this is a project phase where the architect has not yet been selected. Besides, when the architect has been selected and materialization of a specific architectural variable (such as the door) is on the table, discussions between the project team and contractor on associated trade-offs might be more cost-driven compared to a setting where end-users and their workflows are directly represented, or this interest is secured in firmly established qualitative design requirements.

Although hospital staff and real estate departments may have a notion of what a 'healing environment' entails, they often lack the ability to operationalize this concept using EBD knowledge. This lack of operationalization skills (and visualization tools) then hampers them in formulating qualitative design ambitions and guiding conceptual decisions, predating the architect's involvement. Likewise, not all architects working in healthcare have been trained to use EBD-knowledge in their practice or appreciate this added value. Additionally, the position of the project lead on a design and construction project (as an in-house professional or an outside consultant) can influence the engagement of relevant stakeholders, such as in-house experts and end-users, during the successive project phases.

## 5. Discussion and Conclusions

Trade-offs are a fact of life in the field of healthcare design. This awareness of dealing with trade-offs is an important enabler to serve patient safety and patient well-being in a multi-facetted design solution. In this case study, we explored decision-making processes around the design of the door between the semi-public corridor and the private single room and the trade-offs associated with this specific multi-facetted design solution. We found that every advantage can lead to the discovery of new disadvantages. For example, the advantage of acoustic privacy when discussing sensitive matters with your physician from the solid door comes at the cost of compromised dignity, as a HCW cannot hear the response to knocking on the door before entering the patient room (all related to patient

well-being). Likewise, windows in the door with blinds need to be operated by a HCW when the patient cannot get out of bed, and corridor lights need to be seriously dimmed to prevent unwanted light from shining into the room at night time (again, patient well-being). The suggested privacy curtain at the door, a solution expected to solve both issues (and, supporting efficiency and effectiveness of staff), was vetoed by the IPC experts as this curtain could be a potential source of microbial transfer and lacks a clear 'owner' when it comes to frequent washing (patient safety). A main challenge in EBD and evaluation research lies in raising awareness of these trade-offs for all parties involved and in successive project phases. This requires the engagement of stakeholders, such as end-users and experts, echoing earlier findings by Reijula and Taylor [35, 36]. It also illustrates that the EBD knowledge has to be interpreted in the unique context of the project [24].

Architects are often seen as the primary source of EBD knowledge within design projects. Although EBD-knowledge might be lacking in their training or they might take a different position in the 'form follows function' debate in healthcare architecture, they are still seen as the obvious stakeholder to inform design practice with trade-offs encountered in different projects based on POEs. However, in practice in the Netherlands, the functional program of requirements and accompanying room data sheets are often the basis for commissioning the architect, and many fundamental choices (e.g., on the use of single-occupancy rooms) may already have passed. Likewise, end-users are more often engaged as stakeholders during the functional programming phase, compared to being engaged (or represented) in the core design team and directly involved in discussions about design solutions and materialization [35].

Trade-offs in later phases might be EBD-informed by the architect, but they may not be presented within a setting where end-users and experts with their system-specific understanding of workflows can support these arguments. Architects' arguments on behalf of end-users could even be at risk of being overruled by the budgetary concerns of project managers and the construction company. It is not always clear who quality assures prior design commitments during these later design phases, as we saw in the absence of the mirror in our case study. Likewise, we found that the leading principles guiding design decisions (e.g., enhanced patient safety through infection prevention) were not always part of the narrative that was used in the NWW program while preparing HCW for their new work environment. The POE in this case study highlighted once more the importance of understanding HCWs' workflows and incorporating these end-users' input in all project phases [34, 36]. The approach derived from our findings suggests the early-on engagement of EBD knowledge holders combined with prolonged end-user engagement and dialogue. This approach serves not only patient safety and patient well-being but also addresses needs based on efficient and effective staff workflows.

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