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[CASE STUDY: MORE PATIENT SAFETY BY DESIGN – SYSTEM-BASED APPROACHES FOR HOSPITALS]

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ABSTRACT:

Since the publication of the report "To Err Is Human: Building a Safer Health System" by the U.S. Institute of Medicine in 2000, much has changed with regard to patient safety. Many of the more recent initiatives to improve patient safety target the behavior of healthcare staff (e.g., training, double-checking procedures, and standard operating procedures). System-based interventions have so far received less attention, even though they produce more substantial improvements, being less dependent on individuals' behavior. One type of system-based intervention that can benefit patient safety involves improvements to hospital design. Given that people's working environment affect their behavior, good design at a systemic level not only enables staff to work more efficiently, it can also prevent errors and mishaps, which can have serious consequences for patients. While an increasing number of studies have demonstrated the effect of hospital design on patient safety, this knowledge is not easily accessible to clinicians, practitioners, risk managers and other decision-makers, such as designers and architects of healthcare facilities. This is why the Swiss Patient Safety Foundation launched its project, "More Patient Safety by Design: Systemic Approaches for Hospitals," which is presented in this chapter.

KEYWORDS:

(Please supply up to 6 keywords for your Chapter)

1. Hospital design
2. Information dissemination
3. Medical error
4. Patient safety
5. System-based interventions
6. Systemic approach

1. Introduction

A hospital is a complex system where many different experts work together, carrying out difficult activities, often under time pressure. In such a demanding environment, errors do occur. Although medical errors are, ultimately, always made by individuals or teams, their root cause is generally the interaction between humans and their environment (1). Safety can be created, therefore, by designing a system that makes errors unlikely and supports the hospital staff in doing things right. Ever since the U.S. Institute of Medicine report "To Err is Human: Building a Safer Health System" came out in 2000 (2), much research has been conducted on patient safety, often focusing on human behavior. Consequently, many initiatives implemented since then have focused on behavioral aspects. These person-based initiatives aim to improve patient safety by changing the behavior of individual healthcare professionals through training, double-checking procedures, and standard-operating procedures (SOPs). System-based interventions (such as the simplification of processes, improvements to the work environment, or standardization) have received less attention to date, even though they produce more substantial improvements because they rely less on the individual safety behavior of employees (3). In fact, quality expert Edward W. Deming estimated that around 94% of problems and improvement possibilities may be system-based (4).

Despite a great number of patient safety initiatives since 2000, there is still a long way to go to create a safer healthcare system (5–7). One reason for the limited progress of patient safety in recent years could be that wrong conclusions are drawn from event analyses in hospitals. Kellog et al. (2016), for example, showed that professionals often draw conclusions out of error analysis that intend to improve people's behavior. The authors examined the types of solutions proposed in root cause analysis (RCA) over an 8-year period at a major academic medical institution. RCA is a process used by hospitals in an attempt to reduce adverse event rates, although its benefits in a healthcare context has not yet been studied extensively. They gathered data on all state-reportable adverse events analyzed by means of an RCA, and the proposed solutions were studied. In 106 RCAs, 731 solutions were proposed. The most common proposals involved training (20.0%), followed by process changes (19.6%), and policy reinforcement (15.2%). The solutions suggested for changes to forms and other paperwork, the physical environment, and the IT structure were all <5%. In this context, the authors also provided evidence that the number of retained foreign bodies (i.e., foreign bodies left inside a patient after an operation), a serious event in surgery, was unaffected by the proposed measures, highlighting their relative ineffectiveness. These results are astonishing as the safety research literature has suggested that interventions which direct people's behavior are less effective than interventions at a system level (3,8).

One example of system-based interventions are improvements in hospital design. Given that a working environment has considerable potential to affect how people behave, one that is poorly designed will tend to favor preventable adverse events such as infections, patient falls, and mix-ups (9,10). Conversely, good design at a systemic level can help to promote error-free processes and make the best use of people's potential. This means designing a work environment that helps prevent medical errors or that even to make incorrect actions and processes impossible by forcing people to act in a certain way. As Reason (2000) put it: "Countermeasures are based on the assumption that though we cannot change the human condition, we can change the conditions under which humans work" (1, p. 768) .

Since the early 2000s, an increasing number of studies have demonstrated that hospital design affects patient safety (10). Evidence-based design is defined as the process of basing decisions about an environment to be built on credible evidence, with the goal in this context of improving

healthcare outcomes, including safety (11). However, this knowledge is not easily accessible to clinicians, practitioners, risk managers, or decision-makers in the healthcare setting. This was the reason for the launch of a project with the title “More Patient Safety by Design: Systemic Approaches for Hospitals” by the Swiss Patient Safety Foundation, which is presented in the following. Some of the results included in this chapter have also been published in a brochure which was one of the outputs of the project (12).

2. Conceptual Framework

Any study dealing with hospital design and its impact on human behavior is based on an analysis of human factors, such as the study of the interrelationships between humans, the tools they use, and the environments in which they live and work (13). In the context of patient safety, this means that hospital design should support staff behavior while, at the same time, minimizing risk. Many different aspects of hospital design can affect patient safety. For example, the incidence of falls may increase if the flooring is slippery. Poor lighting affects the performance of employees, increasing their likelihood of making errors. From the perspective of patient safety, hospital design is a diverse, complex, and far-reaching issue. Taking a structured approach, we divided it into four dimensions. As shown in Figure 1 below, in each of them the right design decisions can affect patient safety in a substantial way.

FIG 1 HERE

A. Directly reducing risks

This dimension comprises all aspects of design that constitute a risk or that may directly reduce risk if the relevant decision is taken. Material properties are the crucial factor here. All design aspects under this dimension represent an opportunity or a risk for patient safety, regardless of human behavior. For example, the materials used for surfaces and air filters can have a direct effect on infection rates in hospitals (9,10,14,15).

B. Optimizing latent conditions, supporting staff performance levels

Organizational and systemic factors such as light and noise are also latent conditions that affect employee performance (for example, the ability to concentrate and situational awareness) in all areas of work (1). This increases or reduces the likelihood of errors. Occupational health and health promotion departments have long since realized the importance of these factors in maintaining employee health. Their impact on employee performance is also highly relevant for patient safety.

C. Encouraging intuitive, safety-promoting behavior

This dimension comprises all design aspects that have a positive effect on employee behavior in relation to patient safety. The purpose of design interventions in this dimension is to make it easier to behave correctly than to behave incorrectly. In this dimension, every intervention is aimed at promoting safety-relevant behavior. Staff can be helped to comply with safety rules intuitively by relevant design (10). Door handles in the operating theater designed to be opened with the elbow

are one example, making it easier to comply with rules on hygiene. Some of these approaches are so-called “nudging solutions”. The behavioral psychology concept of a “nudge” is defined as any aspect of the choice architecture that alters people’s behavior in a predictable way without forbidding any options or significantly changing their economic incentives (16). This concept is also used in healthcare settings to influence, for example, people’s safety-promoting behavior (see Chapter 4.5).

D. Creating a health-promoting environment

Many studies have shown that hospital design can have a direct effect on patient recovery and well-being (17,18). This is referred to as healing architecture (19). In addition to the impact of noise on patient recovery (18), for example, a positive correlation has also been identified between access to nature and health outcomes (17). Patients in rooms with windows looking out on a garden, for instance, had far shorter hospital stays, had to take fewer analgesic drugs, and tended to suffer fewer complications than those in rooms with a view of a brick wall (20). The impact of design on patient recovery is particularly well-documented in intensive care (18,21).

In the following, further analysis focuses on the design of the work environment for professional staff in hospitals. It looks mainly at design aspects that optimize latent conditions (B) and positively influence safety-related human behavior (C). While this is not to minimize the importance of the other two areas (A and D), these have already been covered by many studies and initiatives which can be found elsewhere (17,19,22,23).

The following framework (see Figure 2) gives a simplified overview of how solutions from these dimensions (B, C) can influence undesirable events by aiming at latent conditions and the behavior of healthcare professionals.

FIG 2 HERE

An example is used to illustrate the interrelationships: Infections, for example, are a major patient safety issue. One problem is the relatively low hand hygiene compliance in hospitals (compliance with safety rules). To improve compliance by enhancing awareness, quality managers can organize training sessions. It must however be kept in mind that training is directed at individuals and is, therefore, less effective than changes at a system level (3). To improve compliance with safety rules, quality managers might do better to focus on design solutions. One cause of low compliance with hand hygiene rules could be that there are too few dispensers or that they are positioned inconveniently. Birnbach et al. (2010) showed, for example, that it is possible to raise compliance with hand hygiene rules significantly by placing the dispensers in the field of view next to the patients’ beds (nudging solution). This is a good example of how, by making a simple design change (i.e., changing the number and placement of the dispensers), a system-level intervention can enhance hand hygiene without the need for further awareness-raising measures (24).

3. Approach

As stated before, the aim of our project was to consolidate research and practitioners' expertise and to disseminate patient safety design knowledge among healthcare professionals.

As a first step, the project identified the main emergent topics in the field through a comprehensive literature review. We reviewed scientific and grey literature in the field of patient safety and hospital design/architecture to gain a broad understanding of topics and projects. We did not restrict ourselves to a specific time period; most of the literature found appeared after 2000.

In a second step, we organized two expert workshops with 24 experts in Switzerland. We identified the experts by searching for projects in the healthcare sector which involved design and patient safety aspects. Additionally, we used our professional network to obtain recommendations. The expert panel consisted of hospital architects, engineers, designers, quality managers, physicians, occupational health specialists, healthcare professionals, risk managers, and other decision-makers in the healthcare setting.

The first expert discussion aimed at identifying main topics and good practices in the field. To sharpen the experts' focus of the project, they were given an input presentation. Afterwards, we invited the experts to brainstorm and thus create good practices in this area, which were afterwards allocated to the two design dimensions (B and C, see also the conceptual framework in Chapter 2 of this article). The solutions supplied by participants came from concrete projects they had conducted as well as from scientific literature cited by them.

After the workshop, the project team synthesized the collected information and divided it into seven categories (noise, lighting, interruptions, heterogeneity of rooms, standardization, visibility of patients, multifunctionality, and compliance with safety rules).

In a third step, we presented the categories to the experts during a second workshop and discussed them. The experts were able to add further good practices. In the second part of the workshop, the experts ranked the categories, agreeing on the following five topics as having the highest potential to improve patient safety by design in hospitals: lighting, noise, interruptions, standardization, and nudging to enhance compliance.

In a fourth step, the project team developed a practitioner-oriented brochure, which has been published in three Swiss national languages (German, French, and Italian) and in English. The brochure contains an introduction to a systemic approach to patient safety and hospital design and good practice examples of our five topics. They are illustrated by combining research findings, examples of design measures, and key questions for analysis in hospitals. To disseminate the brochure among practitioners in Switzerland, it is distributed via various electronic channels to healthcare professionals in hospitals (e.g., physicians, nurses, quality managers, patient safety experts, and facility managers) as well as hospital architects, designers, and researchers.

In a final step, a symposium with renowned national and international speakers was held in April 2017 to bring together experts from different fields, inform about national and international safety improvement projects and research, and encourage discourse in Switzerland on systemic approaches to improve patient safety.

4. Project Results: Good Practices for Improving Patient Safety by Design

In this sub-chapter, the identified five core topics of patient safety are presented in detail and scientific evidence for their impact is reviewed. The topics play a role throughout many hospital routines and thus affect a large number of staff members.

4.1. Optimizing Lighting

Light is a key design parameter that can have a direct effect on patient safety. For example, a direct correlation exists between light intensity and medication errors. Tasks that require good vision can be performed better in good lighting conditions (25). Buchanan et al. (1991) showed that medications are dispensed with significantly fewer errors at lighting levels of 1,500 lux compared with a lighting intensity of 450 lux (2.6% versus 3.8%) (26). It is important for the light intensity to be adjusted to reflect the specific activity taking place. Generally, bright light has a positive impact on both patients and staff. The need for good lighting increases with age (27). Bright light is particularly important where critical tasks such as distributing and administering medications are performed (10). It should be borne in mind, however, that very bright light can be blinding, which, in turn, causes stress. Situational adjustment of lighting to reflect the activity to be performed should be considered. Lighting in patient rooms might be adjusted during examinations or consultations to keep staff and patient alert, facilitate clinical observations, and minimize the risk of mix-ups. As well as lighting levels, light intensity should be taken into account as this can affect staff alertness or determine whether colors are reproduced correctly or incorrectly (for example with respect to skin tone). The right balance between competing aspects such as patient safety and well-being needs to be struck when deciding on lighting conditions (e.g., screen displays of equipment in the patient's room at night). Light is therefore a major latent condition that affects staff performance. Changing the lighting conditions is a type of system-based intervention that is relatively simple to implement and does not require major building activities.

4.2. Noise Reduction

There are many sources of noise in hospitals, and noise levels can be substantial (17). In fact, since the 1960s noise levels in hospitals have increased steadily around the world (10). High noise levels cause stress, fatigue, and distraction in professional staff and interfere with communication flow. This makes noise a significant source of error in hospitals, particularly when staff are carrying out critical tasks or have to rely on their working memory (28). Unforeseen noises, in particular, (such as the ringing of a telephone) are distracting, interrupt work steps, and thus promote errors (29). Noise is a latent condition that has a key effect on professionals' performance.

The World Health Organization (WHO) recommends keeping background noise levels below 35 dB during the day and no more than 30 dB at night (28). However, Ulrich et al. (2008) found in their review that actual noise levels in hospitals are usually considerably higher (10,30). The Joint Commission, an organization that accredits and certifies nearly 21,000 healthcare organizations and programs in the United States, also stresses that noise is a potential risk factor for medical and nursing errors. The level of environmental noise should, therefore, be low enough for personnel to hear and understand one another at all times (31).

Alarms on medical devices and work noise such as the closing of doors and tearing open of packages are significant noise sources and are often unnecessarily loud. The problem is compounded by the

use of hard, sound-reflecting materials on furniture, walls, and ceiling surfaces (32). Monitoring and alarms provided by medical apparatus have many positive effects on patient safety. At the same time, however, the number of alarms emanating from this type of equipment has seen a considerable increase in recent years. Many of these alarms may actually be unnecessary (33,34). For example, one observational study of a pediatric hospital found that 99% of alarms on the ward and 87% of alarms in intensive care did not require immediate action (35). Too many irrelevant alarms on medical devices lead to desensitization ("alarm fatigue") and stress in staff, increasing error rates (33,36,37). Correct configuration, adjusting alarm limits to patient status, using alarm-sparing features, and well trained staff can, alongside other measures, significantly reduce the frequency of unnecessary alarms (38–40). Increasing alarm safety can be achieved by addressing and incorporating not only the technical factor of alarms but also human and organizational factors in an integrated approach, as Bach et al. (2018) concluded in their study (41).

Humans also frequently contribute to noise themselves. Once noise levels increase, conversations are held at a far louder level, which, in turn, creates more noise (42). Noise is therefore self-perpetuating. Designating rooms or zones as "quiet zones" not only leads to staff themselves behaving more quietly in these zones but also to colleagues in adjacent areas being less noisy. A similar effect is observed in churches and museums.

The intensive care ward is a special case with respect to noise. Multiple studies have demonstrated the importance of a quiet environment for intensive care patients, and noise has been directly linked to complications, such as delirium or psychoses (18,43–45).

4.3. Reduction of Interruptions

Interruptions are a significant problem for patient safety since they are closely associated with errors. According to a study by the Swiss Patient Safety Foundation, 78% of oncological nurses from various hospitals in Switzerland report that they are disturbed by interruptions or disruptions in the performance of high-quality double-check procedures (46). Trbovich et al. (2010) also indicated that, on average, 22% of the nursing staff's working hours are interrupted while they are administering medication, very often while performing critical tasks (47). Westbrook et al. (2010) showed in an observational study that the occurrence and incidence of interruptions during administration of medications is significantly correlated with the incidence of procedural errors (e.g., lack of hand hygiene) and clinically relevant errors (e.g., wrong dose or wrong time). The frequency and severity of errors in medication-associated activities were positively correlated with the frequency of interruptions. The incidence of major errors increased from 2.3% when drugs were administered without interruptions to 4.7% with four interruptions (48).

A similar situation has been observed in the operating room: The surgical error rate increases significantly with the number of interruptions (49). Considering that, according to an observational study, surgeons are interrupted every 4.5 minutes, this does represent an increased risk for patients (50).

Resuming task activity following an interruption might require returning to a previous step in the process, but this is often omitted (e.g., checking patient identity or hand disinfection), leading to problems. Nursing staff are most often interrupted by nurse colleagues clarifying issues. Family members and pump alarms also frequently cause interruptions (47). An additional challenge for patient safety arises when personnel do not suspend their core activity when interrupted

(multitasking), increasing the likelihood for error. Self-interruptions are another common problem. These could be conversations that are unconnected with the task in hand, or loss of focus (51).

When analyzing the sources of interruptions from a systemic perspective, it becomes clear that hospital design can have a major impact. Process-oriented work room design, for example, can significantly affect whether interruptions occur in the first place. Hence material stores, drawers, and shelves that can be accessed from two sides lead to fewer interruptions. The arrangement of rooms and the design of instruments and equipment such as alarms can also impact interruptions. Interruptions should therefore be viewed as an important latent condition in hospitals indicating poor process and system design, which can have a major effect on performance.

A good example of a means to reduce the risk of errors is the sterile cockpit (52). This design measure could prevent interruptions and distractions by banning all conversation, incoming calls, and other distractions while critical tasks such as the administration of medication are performed. The concept of the sterile cockpit comes from the aviation industry. In 1981, the Federal Aviation Administration introduced it to reduce errors. During critical tasks such as takeoff and landing, crew members were no longer allowed to perform nonessential duties or activities. No similar prohibition was found to exist in healthcare systems. The introduction of such a requirement while conducting critical tasks is, therefore, recommended (47). Colligan et al. (2012) studied the effect of screening off the drug preparation area. Six months following implementation, they identified a significant reduction in interruptions without a single practical training session (53). Huckels-Baumgart et al. (2016) demonstrated how introducing a separate room for medication distribution significantly reduces the number of interruptions. Following the intervention, the average error rate in administering medication fell from 1.3 to 0.9 per day ($p < 0.05$) (54).

4.4. Standardization

Standardization is viewed as an important human factor strategy for reducing error rates and improving quality (2,13). Standardization reduces load on short-term memory and allows people who are not familiar with certain designs or environments to use them safely and intuitively (2). Standardization can thus be beneficial for staff as well as patients and relatives. Standardization of a hospital's fixtures and fittings as well as room design, beginning with the positioning of doors and extending to control of beds and the positioning of the latex glove store, affects human behavior and thus safety (55).

Standardization offers many opportunities for supporting patient safety. For example, how you provide and position objects, tools, and instruments affects staff reaction times, with a huge impact on patient safety. In emergencies, time is a key factor. If you have to search for the emergency kit because it is not always stored in the same place, patient safety is at risk. Reaction times are also improved if, for example, the displays of modern technical equipment are standardized so that users do not constantly have to adapt.

Grigg et al. (2017) examined the impact of an anesthesia medication template (AMT), which was created by a team of physicians and designers at the University of Washington to decrease medication errors in anesthesia. The results illustrate that the standardizing of medication administration using an AMT is an intuitive, low-cost strategy with the potential to improve patient safety trough reducing medication errors by anesthesia providers (56).

Standardizing designations of rooms can also affect patient safety, particularly in large facilities with high staff turnover. In emergencies, it is crucial for designations to be standardized and clear to prevent time being wasted. Standardization of patient rooms for different levels of care is another key example. This cuts the need for transfers as well as reducing communication problems, delays, and loss of information (10). Standardization is a key aspect in promoting intuitive, safety-oriented behavior by staff.

However, there are also inherent risks to standardization. The universality of Luer locks (standardized connection system for tubing systems), for example, offers opportunity for dangerous accidental misconnections, causing serious damage. Intravenous drips could be confused with feeding tubes, for example. Due to this international standardization, agencies have defined foolproof connector types for four applications (57). It is always worthwhile checking whether the level of standards and variability of material promotes safety or brings new hazards. The U.S. Food and Drug Administration has also identified Luer locks as an important problem and requires different standards for connectors for each area of application (58).

One common reason why many safety-related devices, materials, and products in hospitals are not standardized is that their design is used by the manufacturers as a feature for brand identification. This often means that very different materials look similar if they are from the same manufacturer, while very similar materials may look very different if they are from different manufacturers. Manufacturers are therefore urged to standardize key components to increase patient safety. The approval process for materials, products and devices should also give more weight to these considerations (59,60).

4.5. Nudging to Raise Compliance

Although healthcare professionals are motivated to avoid errors as much as possible, again and again their behavior leads to preventable adverse events (61). Knowingly or unknowingly, they do not follow standards, make simple cognitive mistakes, and fail to comply with safety rules, all of which may cause serious harm. There may be many reasons for this: contradictory rules, rules that are non-intuitive, or rules with competing purposes and safety aspects.

Often, there is a gap between what we intend to do and what we actually do (61). Hand hygiene is one such example. Every professional knows that many infections acquired in hospitals can be prevented by complying with hand hygiene policies. Yet compliance with hand hygiene is often unsatisfactory. Campaigns focusing on improving behavior or drawing attention to the problem are often short-lived (62).

The question arises as to how design can help to make it easier for healthcare professionals to comply with safety rules, preferably intuitively. One way is by understanding the principles underlying decision-making in certain situations and applying them in a goal-oriented way, for instance by nudging, a concept from behavioral psychology (16). As has been explained earlier, a nudge is any aspect of the choice architecture that alters people's behavior in a predictable way without restricting any options or significantly changing their economic incentives (16). Decision-makers are given a nudge in the direction of the "right decision."

Design can be used to trigger such nudges, an approach that is increasingly used in healthcare (59,60,63). The following examples taken from health promotion illustrate the underlying principles: For instance, executives' consumption of apples at a conference increases if apples are placed at the

front of buffets during breaks and brownies are arranged towards the back. People also tend to eat less if food is presented on small rather than large plates (64). In other words, small interventions can be used to change the basis on which decisions are made. These changes then make it more likely that a different decision will be taken.

The nudging approach also has great potential for improving patient safety. For example, there have already been positive experiences with nudging in hand hygiene (15,24,65), floor markings in operating theaters for correct positioning of the instrument table in the laminar air flow (66), and the design of e-prescribing screens (60). In the latter case, the default setting in the e-prescribing system was adjusted to ensure that the desired prescription for intensive care patients is automatically selected or has to be actively deselected, which made the correct order more likely.

Nudging strategies generally improve compliance with safety rules while the introduction of such changes is mostly quite simple and not expensive. However, the approach does not mean rules are necessarily followed at all times. In many areas of patient safety, 100% compliance would in fact lead to problems. After all, there may well be valid, safety-related reasons for deciding not to comply with a rule in a given situation and prioritizing other aspects. In an emergency, for example, it is more important to disturb someone than to consider a quiet zone.

5. Conclusion

In the above, we present general considerations and good practices on patient safety based on an international literature review and discussions with experts.

Our study provides insights into future research avenues and has practical implications for the field of healthcare management. For example, a greater focus on how to integrate systematic design approaches in the planning process of new hospitals could produce interesting findings. In addition, we suggest creating more data-driven evidence on the four design dimensions we present. Such studies could help decision-makers in creating safer and more efficient healthcare systems.

The aim of our project was twofold: creation of knowledge and dissemination. In Switzerland, our results were published in a brochure that is available to practitioners and presented at a symposium with renowned national and international speakers.

With regard to the creation of knowledge, our challenge had been to combine research findings and practitioners expertise in a relatively new field and then to disseminate it among practitioners from different fields (e.g., health professionals, designer, architects, and quality managers) to create the desired impact. To achieve our goals, we identified important experts in this field (researchers and practitioners) and brought them together, since no such community existed at that time. Involving experts from different fields is a relatively new approach in the area of patient safety improvements, contrary to other research fields (e.g., high reliability organization research, such as aviation safety). The creation of an expert-driven community on systemic approaches to patient safety can, therefore, be considered as an additional contribution of our project.

The composition of the expert group as well as their individual preferences might have caused a bias concerning the type of solutions developed. We tried to counteract these limitations by conducting a comprehensive, systematic literature research to reduce the risk of omitting important patient safety dimensions and solutions.

Concerning the dissemination of the knowledge we had created about the impact of design on patient safety, the aim was to sensitize professionals to the systemic approach based on the findings of several studies that it is not enough to focus just on behavioral dimensions. Practitioners' focus needs to be on design solutions located at a structural level (3). Unfortunately, evaluating the practical impact was beyond the scope and resources of our project. However, we learned that the brochure has been used in renovation and new building projects in various hospitals, in particular to guide discussion between architects, clinicians, and property developers. The patient safety experts involved in the project have been invited to various events, committees, and networks. New collaboration projects involving design and safety experts as well as clinicians have been established at a national level. The sustainability of these efforts has, however, not yet been confirmed. Finally, this project is an example of how a relatively under-investigated topic can be explored using an approach involving both scientific research and practical expertise which may also lend itself to other topics in the field of healthcare management.

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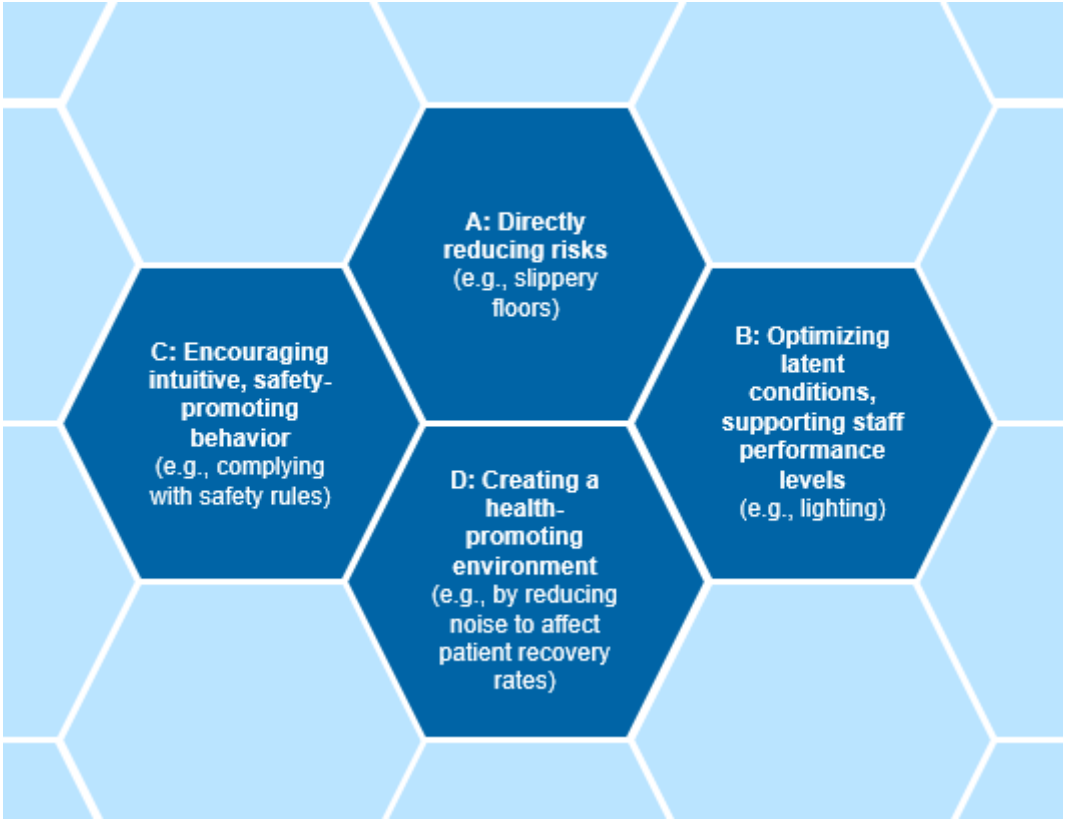

Figure 1: Dimensions of patient safety and design (12)

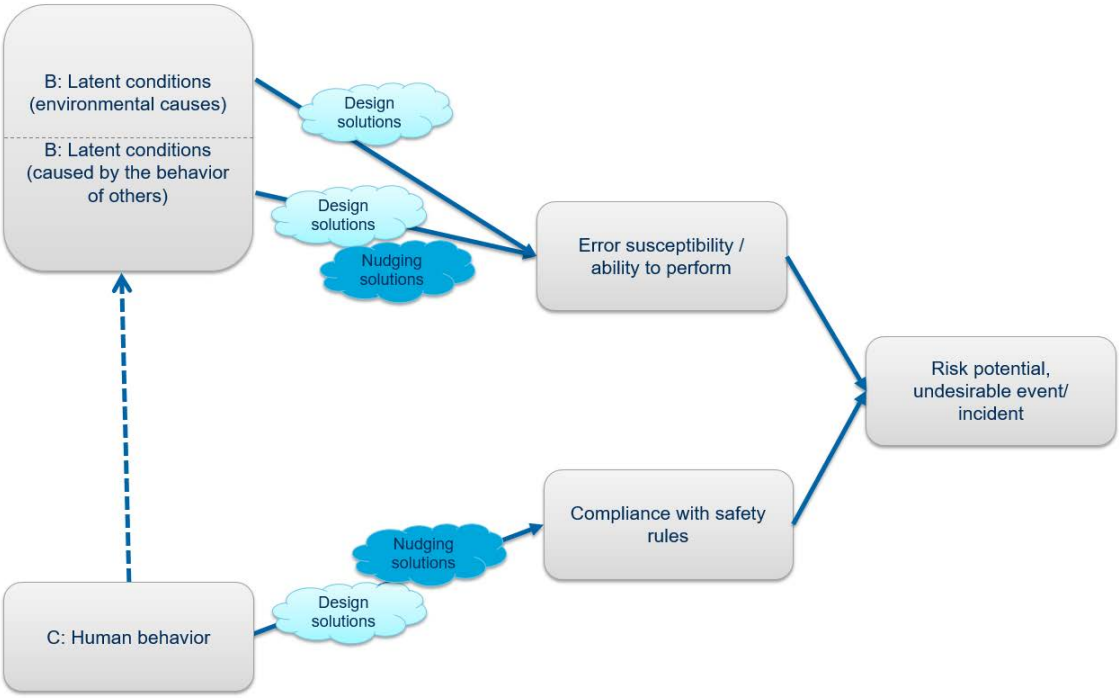

Figure 2: Conceptual framework Design and Patient Safety (own figure)