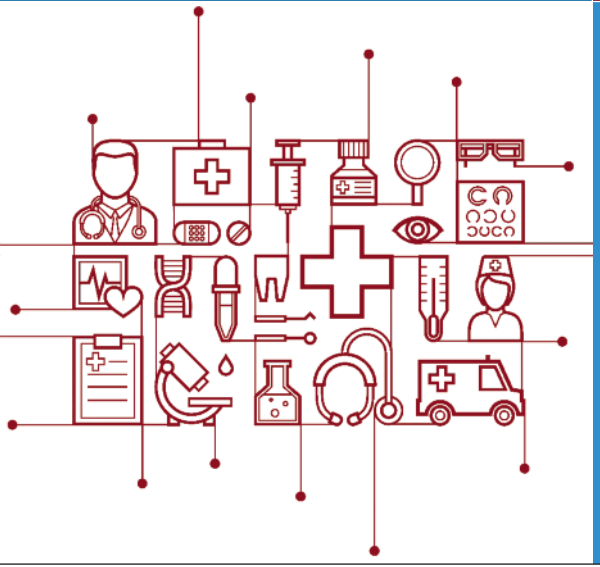
Think Tank

No. 2

Patient Safety Switzerland



More patient safety by design:

Systemic solutions for hospitals

Irene Kobler
Prof. Dr David Schwappach

patient safety switzerland

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INTRODUCTORY REMARKS

A hospital is a complex system where many different people work together, carrying out demanding activities, often under time pressure. Errors do occur. Although medical errors are always ultimately made by individuals or teams, they are generally caused by interactions between humans and their environment (1). Thus safety is a function of the system, not of individuals. Given its enormous potential to affect how people behave, a poorly designed working environment will tend to favor preventable adverse events such as infections, patient falls and mix-ups (2-4). Conversely, good design at a systemic level can help to promote error-free activity and make best use of people's potential.

In practice this means designing the working environment so as to minimize medical errors, or even make incorrect actions and processes impossible. Sometimes solutions require new buildings or structural modifications. But there are also many improvements that can be implemented easily without interrupting the hospital routine.

A comprehensive analysis of factors and working environments that promote errors and impair patient safety is crucial to a design intervention at the system level, regardless of whether the intervention involves a new build or structural modifications, or modifications to current hospital operations. In any project aimed at improving design in order to increase patient safety, the following question is of central importance: What factors and framework conditions of the working environment currently promote preventable adverse events? The answers can then be used to flesh out detailed questions for individual departments. Patient safety executive walkarounds offer one way of identifying design-relevant factors and conditions of working environments. Such inspection tours provide an opportunity for all those involved to familiarize themselves with the specific working environment and support discussion between executives, planners, architects and designers and the professional staff who experience and monitor safety problems in their daily lives. Of course not every design improvement project needs a complete analysis, since many problems are already known and apply to all hospitals.

Humans do not always behave clumsily and do not always err, but are much more likely to when things they use are badly conceived and designed (5).

Where an opportunity occurs to "design in" patient safety to a new build, it is important to consider and integrate this aspect from the outset (6), as happens with fire protection, for example. However, since patient safety is not standardized and regulated to the same extent, it is often ignored, neglected or not explicitly considered at the planning and construction phase. Anjali et al. (2012) developed a Safe Design Roadmap with this in mind. This list helps decision-makers to integrate patient safety into a hospital by design. Key questions at each design phase help to consider patient safety from planning to implementation (6).

Despite these findings the "Designing patient safety into hospitals" approach is little known in Switzerland. This is astonishing given that preventable adverse events not only cause huge amounts of human suffering but also entail high financial costs. If the consequential costs of preventable adverse events are taken

into account, even major investments in building and architecture can be worthwhile.

Significant and sustainable improvements in patient safety can only be achieved by systemic approaches and structural risk reduction.

Again and again there are reports in Cirrnet about structural and design features that pose a risk to patient safety. In some cases these reports have triggered Quick Alerts[1]. For example Quick Alert No. 16 warns of a "door hazard" (download from www.patientensicherheit.ch).

The Swiss Patient Safety Foundation launched the project "More patient safety by design: Systemic solutions for hospitals" to promote the relevance of this topic in practice. This brochure is the outcome of that project. The contents have been compiled on the basis of a literature review and two discussions with expert panels.

This brochure sets out key areas where design can have a concrete, proven impact on patient safety and also suggests approaches for developing solutions in hospitals. The aim is to draw the attention of medical professionals, as well as architects, designers, quality managers, patient safety specialists, hospital managers and other executives, to the connection between design and patient safety and to show how design measures can help to increase patient safety. Our goal is to highlight the importance of spatial and design structures for increasing patient safety.

Please note that the clinical aspects of the preventable adverse events in the examples are not described in detail since the medical context is not directly relevant for these purposes.

[1] Quick Alerts are concisely formulated recommendations and warnings based on relevant and clearly demarcated problems in patient safety.

The following experts took part in the discussions:

- Minou Afzali, Hochschule der Künste Bern HKB
- Yvonne Biri, Kantonsspital Baden
- Felix Bohn, Schweizerische Fachstelle für behindertengerechtes Bauen
- Dr. Volker Büche, Universitätsspital Basel
- Dr. Ute Buschmann, Luzerner Kantonsspital und Vorstand SQMH
- Susanna Caravatti-Felchlin, UniversitätsSpital Zürich
- Prof. Dr. Brigitta Danuser, Institut universitaire romand de Santé au Travail
- Dr. Frank Faulhaber, Universitäts-Kinderspital Zürich
- Prof. Dr. Pietro Giovanoli, UniversitätsSpital Zürich
- Prof. PD.Dr. Tom Guthknecht / Spitalzentrum Biel
- Dr. Dirk Hüske-Kraus, Philips Medizin Systeme (D)
- Irene Kobler, Patientensicherheit Schweiz (Moderation)
- Dr. Nicolò Luppino, Laborplaner Tonelli AG
- Heinrich Messmer, Institut für Beratung im Gesundheitswesen
- Sebastian Meuschke, Metron Architektur AG
- Marlis Pfändler-Poletti, Universitäts-Kinderspital Zürich
- Isabelle Praplan, H+ Die Spitäler der Schweiz
- Dr. Yvonne Pfeiffer, Patientensicherheit Schweiz
- Prof. Dr. Hans Ulrich Rothen, Insel Gruppe Bern
- Simon Schüpbach, Ingenieur Hospital Schweiz
- Prof. Dr. David Schwappach, Patientensicherheit Schweiz
- Anna Suter, Insel Gruppe Bern
- Michael Wehrli, Universitätsspital Basel
- Markus Wiegand, Wiegand AG
- Ute Ziegler, Technik & Architektur Hochschule Luzern

INTRODUCTION TO THE TOPIC

PATIENT SAFETY

Patient safety is defined as 'The avoidance, prevention and amelioration of adverse outcomes or injuries stemming from the process of healthcare' (7). This definition is widely used today. Within the definition a distinction is made between the following key terms:

Error: Medical error is defined as the failure of a planned action to be completed as intended (error of execution) or use of a wrong, inappropriate or incorrect plan to achieve an aim (error of planning). An error may or may not cause harm. Example: The "Allergy" warnings in the patient's file are overlooked when penicillin is prescribed during an appointment; this error may cause harm (8).

An **adverse event** is an injury caused by medical management rather than the underlying disease. An adverse event may be the result of an error. Example: Severe skin reaction following administration of penicillin (8).

Preventable adverse event:
This refers to harm to a patient that is always error-based, for example, a severe skin reaction following administration of penicillin despite the penicillin allergy being noted in the patient's file. Examples of common errors of execution are errors due to inattention (for example, mix-ups) and failures of memory (for example, forgetting a planned step) (8).

Just twenty years ago, treatment errors were barely discussed in the medical literature. The publication of the report "To Err is Human: Building a Safer Health System" by the Institute of Medicine in the United States fundamentally changed how errors in healthcare are viewed. This report was the first time that harm caused by healthcare itself was identified by name and its dimensions set out properly, rather than being seen as an inevitable element of modern medicine. People realized that most errors are not due to individual failure. Their occurrence should be viewed from a systems perspective. Adverse events are the outcome of many minor omissions at individual and organizational level, concrete or latent, which are not captured in time by safety barriers. The publication went on to call for measures to be implemented at all levels of the healthcare system to improve patient safety (9).

In Western countries around one in every thousand patients dies from a preventable adverse event (10). A rough extrapolation of this figure to the Swiss population translates into a minimum of 700–1,700 error-induced fatalities per year, depending on whether the number is based on the population or takes the differences in hospitalization rates between countries into consideration. Based on these data, Makary and Daniel (2016) make the provocative statement that if medical error was a disease, in the United States it would rank as the third leading cause of death (11).

Since the publication of the report "To Err is Human: Building a Safer Health System" (9) a great deal has happened with regard to patient safety in Switzerland, too. Examples of this include the introduction of the surgical checklist to prevent adverse events in the operating theater, widespread use of event reporting systems (e.g. CIRS), training courses, team training or measures to improve hand hygiene. A large number of these initiatives are directed at people's behavior. They aim to improve patient safety by changing the behavior of individual healthcare professionals. Structural interventions relating to the design

of the working environment have so far received less attention, both nationally and internationally.

However, interventions aimed at directly influencing people's behavior normally produce only minor substantial improvements to patient safety over the long term. The more an innovation depends on human behavior, the less effective it tends to be in practice. There are many different reasons for this: On the one hand such interventions rely on staff remembering what they have learnt and applying that behavior at all times, even under time pressure and in critical situations (12). On the other hand, how staff actually behave will always be conditional on a number of different requirements which have to be taken into account by the staff and which may even be contradictory or competitive.

Adjustments at system level are more effective since they are only slightly dependent on conscious actions. Improvements in hospital design (organization, equipment, layout etc.) operate at precisely this system level.

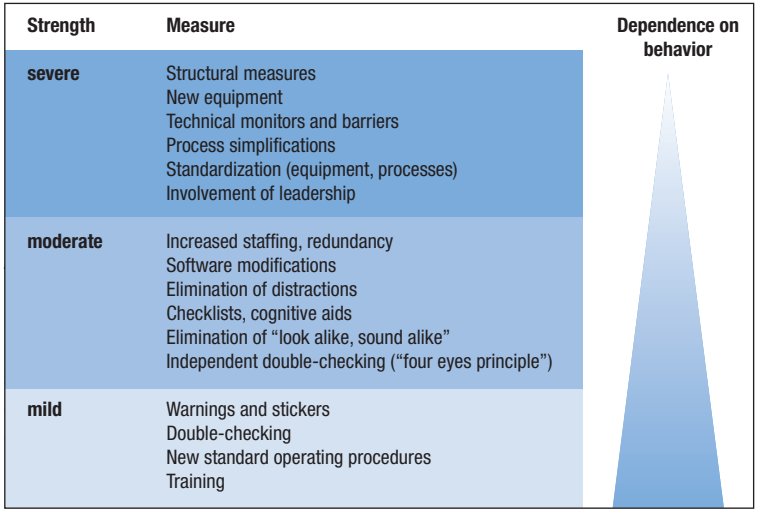


Fig. 1: St. Pierre M. Hofinger G. Human Factors und Patientensicherheit in der Akutmedizin (3. Auflage). Berlin: Springer-Verlag; 2014. With permission of Springer.

EVIDENCE-BASED HEALTHCARE DESIGN

A systemic approach focuses on various factors that help to create conditions which cause or promote errors in hospitals. These may include the lack of financial and time resources, communication problems and the lack of information, lack of technical equipment at the hospital and indeed a poorly designed working environment for professionals. These factors can support or impede safe actions by medical professionals. An increasing number of studies demonstrate that design affects patient safety (3). Not only healthcare itself but the *organization* of medicine should be evidence-based. Evidence-based design is the process of basing decisions about the built environment on credible scientific evidence to achieve the best possible outcomes. This is a fundamental change in thinking. The design process starts by identifying key principles that describe how an organization can achieve these goals (for an example of this see "The Center for Health Design".

Any study dealing with hospital design and its impact on human behavior is based on an analysis of *human factors*, i.e. the "study of the interrelationships between humans, the tools they use and the environments in which they live and work" (13). What this means for design and patient safety is that design should support staff behavior whilst at the same time minimizing risk (4). Today, evidence-based design is increasingly being introduced into healthcare. Evidence-based design is used, for example, to speed up recovery times or reduce the pain experienced by patients, e.g. by using the acoustic environment or by connecting to the natural environment (14).

Reiling et al. (2006) developed the patient safety design principles, which can be applied to all healthcare facilities whether they are new buildings, renovations or existing buildings (15).

Using such defined design principles and process recommendations ensures that all those involved in the design process are pursuing a shared goal and are focusing on patient safety together (15). They can act as a "memory aid", foregrounding central aspects in a systematic way, over and over again.

Patient safety design principles:

1. Noise reduction
2. Scalability, adaptability, flexibility
3. Visibility of patients to staff
4. Patients involved with their care
5. Standardization
6. Automate where possible
7. Minimizing fatigue
8. Immediate accessibility of information, close to the point of service
9. Minimizing patient transfers/handoffs
10. Design around precarious events:
    - Operative/post-op complications/infections
    - Inpatient suicides
    - Correct tube – correct connector – correct hole placement events
    - Medication error-related events
    - Wrong site surgery events
    - Oxygen cylinder hazards
    - Deaths of patients in restraints
    - Transfusion-related events
    - Patient falls
    - MRI hazards

Fig. 2: Patient safety principles according to Reiling et al. 2006 (15)

DESIGN CONSIDERATIONS

Many different aspects of hospital design can affect patient safety: For example, the incidence of falls may increase if flooring is slippery. Poor lighting affects the performance of employees, making errors more likely.

Hospital design and patient safety is a diverse, complex and far-reaching issue. We have divided it into four dimensions to take a structured approach: These are four basic dimensions in which design can affect patient safety and where changes can be effected by action at the design level. There are of course other strategies and policies that can be used to address this issue.

We summarize these dimensions below:

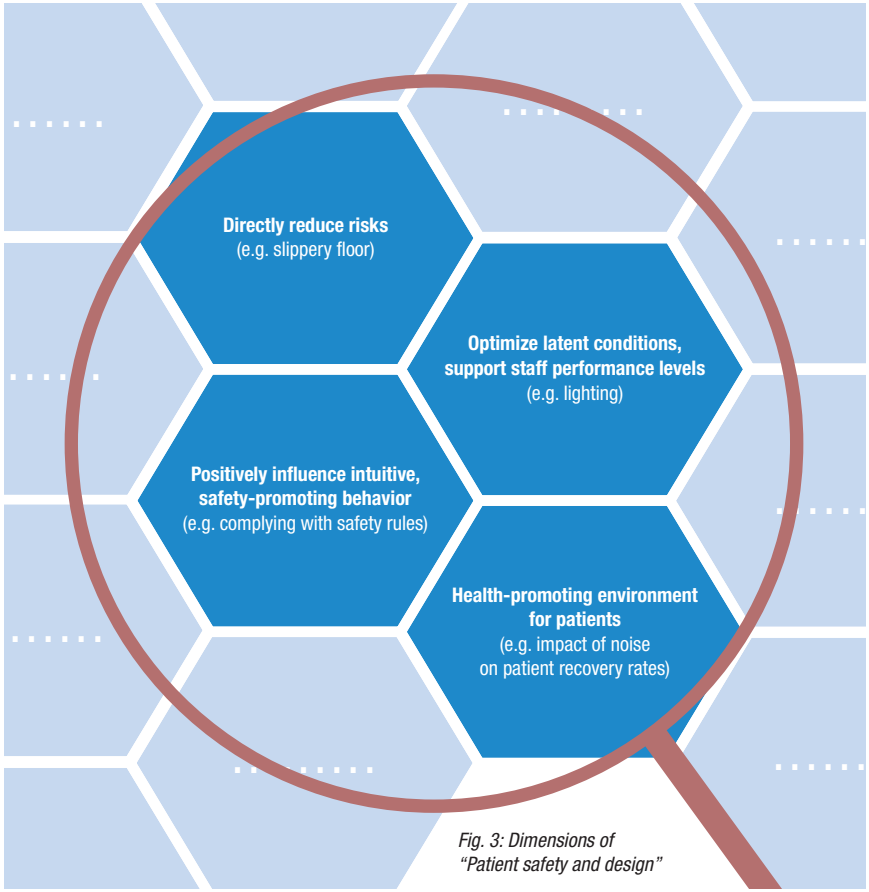


Fig. 3: Dimensions of "Patient safety and design"

Directly reduce 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 choice of floor covering can have a considerable effect on patient fall rates. The materials used for surfaces, or the air filters used, can have a direct effect on infection rates in hospitals (3;16-18).

Optimize latent conditions that support staff performance levels

Organizational and systemic factors such as light and noise are latent conditions that affect employee performance (for example ability to concentrate) in all areas of their work (1). This increases or reduces the likelihood of errors and applies to hospitals as well. 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.

Positively influence intuitive, safety-promoting behavior

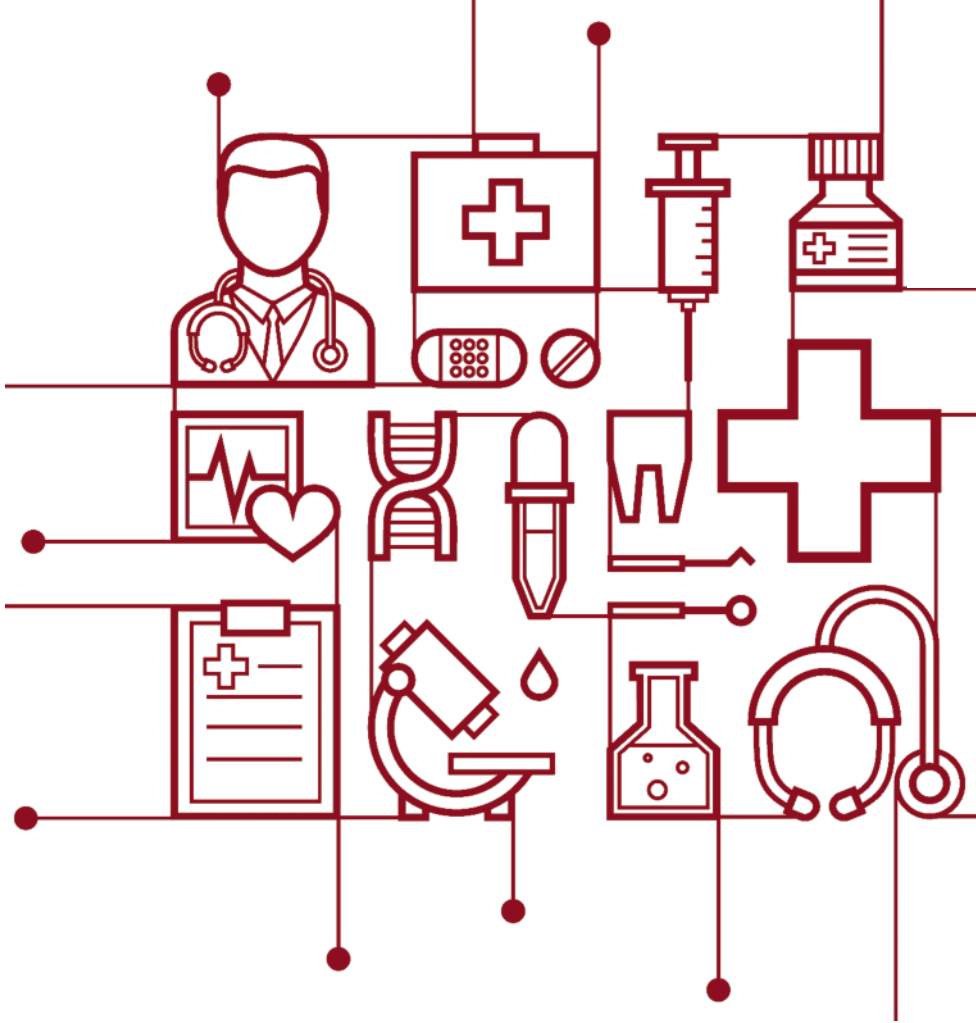
This dimension comprises all design aspects that positively affect employee behavior in relation to patient safety. The purpose of design interventions in this dimension is to make it easier to behave correctly than to behave incorrectly. In this dimension, every intervention is aimed at promoting safety-relevant behavior. Staff can be helped to comply with safety rules intuitively by relevant design (17). Door handles in the operating theater designed to be opened with the elbows are one example of this dimension, making it easier to comply with rules on hygiene.

Health-promoting environment for patients

Many studies show that hospital design can have a direct effect on patient recovery (19;20). This is referred to as healing architecture (21). In addition to the impact of noise on patient recovery (20), for example, a positive correlation has also been identified between access to nature and health outcomes (19). Patients in rooms with windows looking out on a leafy environment had far shorter hospital stays, had to take fewer analgesic drugs and had rather fewer complications than those in rooms with a view of a brick wall (22). The impact of design on patient recovery is particularly well attested in intensive care (20;23).

This brochure focuses on the design of the working environment for professional staffs in hospitals. It looks mainly at design aspects that optimize latent conditions and positively influence safety-related human behavior. This is not to minimize the importance of the other two areas. However these are already covered by many studies and initiatives which can be found elsewhere (3;20;24;25).

Five topics selected with a group of experts are presented below. They relate to issues that play a role throughout hospital routines and thus affect large numbers of staff. The solutions can not only be applied to new buildings but also adapted for use in existing buildings. As well as general background information they contain tips, key issues for analysis and examples of design measures.



light

Tip: Let there be light

Poor lighting is a source of error that can cause all sorts of confusions and should be taken seriously. Lighting conditions affect professional performance. Lighting conditions have a major effect on the likelihood of error when completing critical tasks. Appropriate lighting conditions are increasingly important with increasing age.

1 LIGHT

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. Actions that require good vision can be performed better in good lighting conditions (26). Buchanan et al. (1991) showed that medicatons 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%) (27). It is important that the light intensity is 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 (28). Bright light is particularly important where critical tasks such as distributing and administering medications are performed (3). But it should be borne in mind that very bright light can be blinding which in turn causes stress. Situational adjustment of lighting to reflect the activity should be considered. Light 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.

Example: The exterior of a hospital is undergoing renovation and scaffolding has been erected. Little light reaches the medication stock room, representing a drug safety risk.

LIGHT AFFECTS:

- Fatigue/concentration
- Vision
- Risk of mix-ups, e.g. risk of medication mix-ups

KEY ISSUES FOR ANALYSIS:

- Which staff carry out critical tasks requiring good vision? At what sites/work stations? What lighting requirements are there and how can these be optimized?
- In what situations/rooms are there competing requirements for lighting? Can certain tasks be moved to a different location?
- At what work steps do mix-ups and other errors frequently occur? Is it possible that these are linked to lighting conditions (lighting levels and light quality)?

EXAMPLES OF DESIGN:

- Medication distribution sites with appropriate lighting equipment
- Luminous displays for equipment that can also be seen at night (e.g. temperature reading displays)
- Adjustment of light intensity anywhere critical tasks are carried out
- Adaptable light sources: manually (dimmer switch) or automatically (e.g. if someone is in focus for a defined period)
- Mobile light sources

quiet

Tip: In quietness is strength

A loud environment and in particular sudden noise sources distract staff from their tasks and cause stress. Speech is more difficult to understand and staff communications suffer. Human beings are often the cause of self-perpetuating noise: People speak louder in louder environments. Noise from work and alarms also increase noise levels.

2 QUIET

There are many sources of noise in hospitals and these noises are often very loud (19). Noise levels in hospitals have increased steadily around the world since the 1960s (3). High noise levels cause stress, fatigue and distraction in professional staff and interfere with communication flows. 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 (29). Unforeseen noises in particular (such as the ringing of a telephone) are distracting, interrupt work steps and thus promote errors (30). 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 (29). However, Ulrich et al. (2008) point out in their review that actual noise levels in hospitals are usually considerably higher (3;31). The US Joint Commission also emphasizes that noise is a potential risk factor for medical and nursing errors. The authors stress that the level of environmental noise should be low enough for personnel to hear and understand one another at all times (32).

Alarms on medical devices and work noise such as closing of doors and tearing open packages are significant noise sources. Most of these noises are unnecessarily loud. The problem is compounded by the use of hard sound-reflecting materials on furniture, wall and ceiling surfaces (33). Monitoring and alarms provided by medical apparatus have many positive effects on patient safety. At the same time, however, the number of alarms on these sorts of equipment has seen a huge increase in recent years. Many of these alarms are actually unnecessary (34;35). 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 (36). Too many irrelevant alarms on medical devices lead to desensitization ("alarm fatigue") and stress in staff, increasing error rates (34;37;38). 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 (39-41).

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 in the intensive care ward such as delirium or psychoses (20;43-45).

[2] USA accreditation and certification body

Example: A junior doctor gives a member of the nursing staff important information about a patient's further treatment. The noise levels are already high due to construction noise. At the same time, the telephone is ringing and a conversation is going on between two other nursing staff. Important information is lost in transmission.

QUIET AFFECTS:

- Stress
- Performance
- Distraction, ability to concentrate
- Communication flows
- Alarm fatigue
- Medication safety, mix-ups in general

SOURCES OF NOISE:

- Staff
- Alarms
- Technical equipment such as pagers, general work equipment, trolleys etc. (33)
- Work noises (such as closing of doors, closing bed rails etc.)
- Number of patients in the room
- Relatives
- Cleaning equipment
- Architecture (e.g. long corridors are conducive to noise echoing (19))

KEY ISSUES FOR ANALYSIS:

- How can 'work noises' such as the noise of a door closing be reduced?
- Where can noise-suppressant materials be used in the hospital?
- How can staff noise levels be reduced in rooms where critical tasks are being carried out?
- What is the cause of self-perpetuating noise? How can design measures be used to break this cycle?
- Are there alarms that are essentially superfluous or unnecessarily loud?
- Can alarms be reduced systematically and safely?

EXAMPLES OF DESIGN:

- Noise-absorbing surfaces (for example, floor coverings, surfaces)
- Quiet devices, work instruments/materials (e.g. cardboard dishes instead of metal kidney dishes)
- Reduction of unnecessary alarms (e.g. noiseless pager systems)
- Single rooms (but also entail disadvantages, see (46))
- Designated zones/rooms for talking to colleagues (e.g. communication niches (47))
- Quiet zones for work requiring concentration

inter-ruptions

Tip: Do not disturb

Interruptions distract staff performing their core duties, causing them to lose focus and constantly have to pick up where they left off. This encourages errors to occur such as mix-ups, forgetting work steps or losing information. The working environment can be designed in such a way as to reduce interruptions.

3 INTERRUPTIONS

Interruptions are a significant problem for patient safety since they are closely associated with errors. 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).

Trbovich et al. (2010) also indicated that on average 22% of nursing staff working hours are interrupted while they are administering medication, very often while performing critical tasks. Resuming an 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 (49). An additional challenge for patient safety arises when personnel do not suspend their core activity when interrupted (multitasking) and thus act in a very error-prone way.

Self-interruptions are another common problem. These could be conversations that are unconnected with the task in hand, or loss of focus (50).

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 which can have a major effect on performance.

A striking example of how errors can be reduced prospectively is the sterile cockpit (51). This design measure aims to prevent conversations, telephone calls and distractions during critical tasks (49). 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 (52). 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 medication also fell from 1.3 to 0.9 per day ($p < 0.05$) (53).

Deliberate interruptions such as Team Time Outs in the operating theater or huddles after minor incidents are not treated here[3].

Example: A nurse preparing medication is interrupted several times. Colleagues ask questions, someone asks for help and a relative comes to clarify a question. The nurse has to refocus on the work after each interruption.

INTERRUPTIONS AFFECT:

- Distraction, concentration
- Performance
- Forgetting work steps and information
- Mix-ups such as medication errors and handoff errors
- Hygiene

KEY ISSUES FOR ANALYSIS:

- How can we create an environment that allows staff to work together and share information but also enables them to concentrate where necessary?
- Which rooms in our organization are not optimally designed for the processes and therefore give rise to interruptions?
- How can the working environment be organized so that staff are not interrupted when carrying out critical tasks?
- What design measures could support desired interruptions?

EXAMPLES OF DESIGN TO REDUCE INTERRUPTIONS:

- Visual display of important information (e.g. white boards (54))
- Wearing high-visibility jackets to prevent interruptions while carrying out critical tasks (e.g. preparing medication)
- Sterile cockpit (49)
- 'No interruption area', for example demarcated by colored sticky tape (55)
- Process-oriented room design
- Screened areas for carrying out tasks requiring concentration (52;56)
- Separate rooms for preparing medication for distribution (53)

[3] Huddles are convened immediately after minor adverse events (e.g. in medication). The aim is to analyze the event quickly and promptly (49).

standar-dization

Tip: Keep things the same – wherever it makes sense

The standardization of work stations, equipment and their positioning supports human cognitive capacity to act and thus improves reaction times and reduces incidence of errors or avoidable dangerous loss of time. However it is critical to check where standardization increases safety and where it poses a hazard. Each case should be examined carefully to ensure that the right balance has been struck between standardization and distinctiveness.

4 STANDARDIZATION

Standardization is viewed as an important *human factor* strategy for reducing error rates and improving quality (9;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 (9). 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 (15).

Standardization offers lots of 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. Take for example emergencies where time is a key factor. If you have to search for the emergency kit because it is not always stored in the same place, this has a significant impact on patient safety.

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. Standardizing designations of rooms can also affect patient safety, particularly in large facilities with high staff turnover. In emergencies it is crucial that designation is 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 losses of information (3). Standardization is a key aspect for supporting intuitive, safety-oriented behavior by staff.

There are risks inherent in standardization, too. The universality of Luer locks (standardized connection system for tubing systems) is almost bound to create accidental misconnections, causing huge damage. Intravenous drips could be confused with abdominal probes, 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 US 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 the design is used by the manufacturers as a feature for brand identification. This often means that very different materials look similar to each other if they are from the same manufacturer, whilst very similar materials look very different from one another 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.

Example: A patient is showing signs of hypoglycemia. The nursing officer wants to measure blood sugar but cannot find the required device right away since there is no designated storage space for it. This causes a delay in patient care.

STANDARDIZATION AFFECTS:

- Reaction time/capacity to act
- Safe and rapid use of materials
- Safe and rapid locating of equipment and rooms
- Focus on medical aspects of treatment
- User-friendliness, operability, usability
- Transfers (if patient rooms have standardized fittings for different stages of care)

KEY ISSUES FOR ANALYSIS:

- How can we design the professional working environment in hospitals so that it is standardized yet allows for individual requirements?
- What work stations, instruments and equipment could be standardized in our hospital in order to increase patient safety?
- Where does standardization pose a danger (see example of Luer locks)?

EXAMPLES OF DESIGN FOR STANDARDIZATION

- Fixtures on headwalls (e.g. connections for O_2) in patient rooms
- Fixtures and fittings in treatment rooms
- Instruments/equipment, particularly where they are used in emergencies
- Positioning instruments/equipment (care station) (59))
- Work rooms

compliance with rules

Tip: A nudge in the right direction

Through small changes to the choice architecture, professionals can be supported to make the "right" decisions, so that they comply with safety rules more consistently. Nudging is a behavioral psychology concept that describes this perfectly. Nudging strategies make compliance with certain safety rules more likely, but they do not mean that rules are followed without exception.

5 COMPLIANCE WITH RULES

Although healthcare professionals are motivated to avoid errors as much as possible, again and again their behavior leads to preventable adverse events (60). Knowingly or unknowingly they fail to comply with safety rules and may cause harm. There may be many reasons for this: contradictory rules, rules that are non-intuitive, and rules with competing purposes and safety aspects. There is a gap between what we intend to do and what we actually do (60). Hand hygiene is one 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. Activities focusing on behavior or drawing attention to the problem are often short-lived (61).

The question arises: How can design help to make it easier to comply with safety rules, preferably intuitively?

Patient safety can be improved by influencing the way professionals act so that safe actions become intuitive. Design is one potential way of doing this. The principles underlying decision-making before these actions need to be understood and applied in a goal-oriented way. *Nudging* is a behavioral psychology concept that describes this perfectly (62). A nudge is 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 (63). Decision-makers are given a nudge in the direction of the "right decision". Design can be used to trigger such nudges. This approach is now increasingly being introduced in healthcare (64-66). The examples below taken from health promotion indicate the underlying principles. For example, 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 (67). 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 (17;63;68); with floor markings in operating theaters for correct positioning of the instrument table in the laminar air flow (69); and with the design of e-prescribing screens (65). In the latter case the default setting in the e-prescribing system was adjusted so that the desired prescription for intensive care patients is automatically selected and has to be actively deselected. This made it easier to act correctly.

Nudging strategies generally improve compliance with safety rules. However the approach does not mean rules are followed at all times. In many areas of patient safety, 100% compliance would in fact lead to problems. After all, there may well be good, safety-related reasons for deciding not to comply with a rule in a given situation and prioritizing other aspects.

Example: Catheter-associated urinary tract infections (CAUTIs) are some of the most common hospital-acquired infections around the world (70). Many catheters are actually unnecessary. There are frequently alternatives to the transurethral indwelling catheter. However, these are seldom used in practice, frequently out of habit. It is thus important for staff to be inspired to ask themselves, before inserting a catheter, whether there might be alternatives. One way of doing this is by positioning the alternatives at eye level at the sites where catheters are dispensed to encourage their use. Nudging is about making the desired options as easy or even easier to access than the undesirable options.

KEY ISSUES FOR ANALYSIS:

- What safety rules are not complied with at our hospital? Are there any that could be influenced by design?
- How can we change the choice architecture so that safe actions are more beneficial and more intuitive?
- Where can adjustments to sizes, positioning (e.g. on shelves), positioning at eye level, targeted use of default settings etc. be used to improve patient safety?

POSSIBLE STRATEGIES AND EXAMPLES OF DESIGN:

- Opt-in/opt-out, commonly used in the design of electronic systems (65;66) and organ donation (active consent to organ donation versus active rejection of organ donation) (62)
- Visual communication (e.g. adhesive tape to mark correct position of instrument table in the laminar air flow (69).
- Positioning and arrangement of equipment (e.g. positioning of disinfectant dispensers at eye level (71), care units with essential materials for patient care (e.g. disinfectant dispensers, gloves, space for documentation etc. (59))
- Design and arrangement of rooms (e.g. communication niches for informal sharing of information between staff in the corridors (47))
- Fixtures and fittings (door handles in the operating theater that are designed to be opened with the elbow)

STRUCTURAL AND PROCEDURAL MEASURES

In this brochure we have selected specific, relevant topics and listed examples and suggestions under each topic illustrating how existing structures can be optimized, even in a simple way.

However, in order to achieve long-term, major impact, design and patient safety need to be in lock step. Structural and procedural measures are fundamental to this approach. Expert discussions produced the overarching aspects set out below. These are viewed as essential. The list is not definitive; however, the aspects presented form an important foundation on which to establish design measures to improve patient safety in practice.

- In order for design solutions to improve patient safety and achieve cost savings in the long term more evidence and data is required. This can be used to persuade decision-makers that design solutions will improve patient safety, particularly where these solutions are associated with high costs.
- A carefully considered operational concept that takes account of patient safety is a fundamental element of any new building or renovation. Such a concept binds architects, who can only act within its parameters. Hence it is important that patient safety is included in such concepts from the beginning.
- A bottom-up approach is required. It is only by talking to professionals that their concerns about the working environment can be included. If planning is discussed and agreed based on professionals' needs on site, the working environment will be much closer to day-to-day requirements. This should take into account the fact that not only medical professionals can provide helpful suggestions, but also staff from secondary and tertiary areas such as sterile goods provision, catering or disposal.
- Healthcare staff should have the opportunity to try out certain things and give feedback (e.g. fixtures and fittings in patient rooms through mock-ups and simulations).
- Patient safety executive walkarounds: These inspection tours support discussion between clinical professionals who experience safety problems in their daily lives, and executives, planners, architects and designers.
- Patient safety needs to be considered and tested in the materials design phase. It is also important to involve staff at every phase to test alternatives and pilot new materials.
- Education and training: Specialist architects and designers need to familiarize themselves with patient safety. Healthcare decision-makers need to gain an in-depth knowledge of the benefits of design in improving patient safety. Targeted interdisciplinary training is one way of networking the two disciplines and aspects. In London, Imperial College and the Royal College of Art have identified this gap and launched a joint Masters in "*Healthcare & Design*".

REFERENCE LIST

(01) Reason J. Human error: models and management. BMJ 2000;320(7237):768-70.

(02) Joseph A, Rashid M. The architecture of safety: hospital design. Current Opinion in Critical Care 2007 Dec 1;13(6):714-9.

(03) Ulrich RS, Zimring C, Zhu X, DuBose J, Seo HB, Choi YS, et al. A Review of the Research Literature on Evidence-Based Healthcare Design. HERD: Health Environments Research & Design Journal 2008 Apr 1;1(3):61-125.

(04) Karsh BT, Holden RJ, Alper SJ, Or CK. A human factors engineering paradigm for patient safety: designing to support the performance of the healthcare professional. Qual Saf Health Care 2006 Dec 1;15 Suppl 1:i59-i65.

(05) Norman D. The Design of Everyday Things: Psychologie und Design der alltäglichen Dinge. München: Franz Vahlen München; 2016.

(06) Joseph A, Quan X, Taylor E., Jelen M. Designing for Patient Safety: Developing Methods to Integrate Patient Safety Concerns in the Design Process. The Center for Health Design; 2012.

(07) Vincent C. Das ABC der Patientensicherheit. Schriftenreihe Nr. 4. Zürich: Patientensicherheit Schweiz; 2012.

(08) Schwappach D. Patientensicherheit. In: Egger M, Razum O, editors. Public Health. Sozial- und Präventivmedizin kompakt. 2. Auflage ed. Berlin: de Gruyter; 2014. p. 123-5.

(09) Institute of Medicine. To err is human. Building a safer health system. Washington, DC: National Academy Press; 1999.

(10) Zegers M, de Bruijne MC, Wagner C, Hoonhout LHF, Waaijman R, Smits M, et al. Adverse events and potentially preventable deaths in Dutch hospitals: results of a retrospective patient record review study. Qual Saf Health Care 2009 Aug 1;18(4):297-302.

(11) Makary MA, Daniel M. Medical error - the third leading cause of death in the US. BMJ 2016 May 3;353.

(12) St.Pierre M, Hofinger G. Human Factors und Patientensicherheit in der Akutmedizin (3. Auflage). Berlin: Springer-Verlag; 2014.

(13) Weinger MB, Pantiskas C, Wiklund ME, Carstensen P. Incorporating human factors into the design of medical devices. JAMA 1998 Nov 4;280(17):1484.

(14) Zimring C, Augenbroe GL, Malone EB, Sadler BL. Implementing healthcare excellence: the vital role of the CEO in evidence-based design. HERD 2008;1(3):7-21.

(15) Reiling J. Safe design of healthcare facilities. Qual Saf Health Care 2006 Dec 13;15(Suppl 1):i34-i40.

(16) Sadler BL, DuBose J, Zimring C. The business case for building better hospitals through evidence-based design. HERD 2008;1(3):22-39.

(17) Zimring C, Denham ME, Jacob JT, Cowan DZ, Do E, Hall K, et al. Evidence-based design of healthcare facilities: opportunities for research and practice in infection prevention. Infect Control Hosp Epidemiol 2013 May;34(5):514-6.

(18) Pati D, Valipoor S, Cloutier A, Yang J, Freier P, Harvey TE, et al. Physical Design Factors Contributing to Patient Falls. J Patient Saf 2017 Feb 3.

(19) Ampt A, Harris P, Maxwell M. The Health Impacts of the Design of Hospital Facilities on Patient Recovery and Wellbein, and Staff Wellbeing: A Review of the Literature. Centre for Primary Health Care and Equity: University of New South Wales: Sydney; 2008.

(20) Luetz A, Weiss B, Penzel T, Fietze I, Glos M, Wernecke KD, et al. Feasibility of noise reduction by a modification in ICU environment. Physiol Meas 2016 Jul;37(7):1041-55.

(21) Nickl-Weller Ch., Nickl H. Healing Architecture. Salenstein: Braun Publishing AG; 2013.

(22) Ulrich RS. View through a window may influence recovery from surgery. Science 1984 Apr 27;224(4647):420-1.

(23) Caruso P, Guardian L, Tiengo T, Dos Santos LS, Junior PM. ICU architectural design affects the delirium prevalence: a comparison between single-bed and multibed rooms*. Crit Care Med 2014 Oct;42(10):2204-10.

(24) Lateef F. Hospital design for better infection control. Journal of Emergencies, Trauma and Shock 2009;2009(2(3)):175.

(25) Brandis S. A collaborative occupational therapy and nursing approach to falls prevention in hospital inpatients. J Qual Clin Pract 1999 Dec;19(4):215-20.

(26) Boyce P, Hunter C, Howlett O. The benefits of daylight through windows. Troy, New York: Rensselaer Polytechnic Institute.; 2003 Sep 12.

(27) Buchanan TL, Barker KN, Gibson JT, Jiang BC, Pearson RE. Illumination and errors in dispensing. Am J Hosp Pharm 1991 Oct;48(10):2137-45.

(28) Edwards L, Torcellini P. A Literature Review of the Effects of Natural Light on Building Occupants. Colorado: National Renewable Energy Laboratory; 2002.

(29) Berglund B LTSD. Guidelines for community noise. Protection of the Human Environment: World Health Organization; 1999.

(30) Leather P, Beale D, Sullivan L. Noise, psychosocial stress and their interaction in the workplace. Journal of EnvironmentalPsychology 2003;23(2):213-22.

(31) Busch-Vishniac IJ, West JE, Barnhill C, Hunter T, Orellana D, Chivukula R. Noise levels in Johns Hopkins Hospital. J Acoust Soc Am 2005 Dec;118(6):3629-45.

(32) The Joint Commission on Accreditation of Healthcare Organizations. Comprehensive Accreditation Manual for Hospitals 2005: The Official Handbook. Oakbrook Terrace, IL: Joint Commission Resources; 2004.

(33) Ulrich. Evidence-based health-care architecture. Lancet 2006;368:38-9.

(34) Inokuchi R, Sato H, Nanjo Y, Echigo M, Tanaka A, Ishii T, et al. The proportion of clinically relevant alarms decreases as patient clinical severity decreases in intensive care units: a pilot study. BMJ Open 2013 Sep 1;3(9):e003354.

(35) Siebig S, Kuhls S, Imhoff M, Gather U, Schölmerich J, Wrede CE. Intensive care unit alarms - How many do we need? Crit Care Med 2010;38(2):451-6.

(36) Bonafide CP, Lin R, Zander M, Graham CS, Paine CW, Rock W, et al. Association between exposure to nonactionable physiologic monitor alarms and response time in a children's hospital. J Hosp Med 2015 Apr 1;n/a.

(37) Ruskin KJ, Hueske-Kraus D. Alarm fatigue: impacts on patient safety. Current Opinion in Anesthesiology 2015;28(6).

(38) Sendelbach S, Funk M. Alarm fatigue: a patient safety concern. AACN Adv Crit Care 2013 Oct;24(4):378-86.

(39) Sowan AK, Gomez TM, Tarriela AF, Reed CC, Paper BM. Changes in Default Alarm Settings and Standard In-Service are Insufficient to Improve Alarm Fatigue in an Intensive Care Unit: A Pilot Project. JMIR Hum Factors 2016 Jan 11;3(1):e1.

(40) Paine CW, Goel VV, Ely E, Stave CD, Stemler S, Zander M, et al. Systematic Review of Physiologic Monitor Alarm Characteristics and Pragmatic Interventions to Reduce Alarm Frequency. J Hosp Med 2016 Feb 1;11(2):136-44.

(41) Bell L. Monitor alarm fatigue. Am J Crit Care 2010 Jan;19(1):38.

(42) Joseph A, Ulrich R. Sound Control for Improved Outcomes in Healthcare Settings. The Center for Health Design; 2007.

(43) Mazer SE. Creating a culture of safety: reducing hospital noise. Biomed Instrum Technol 2012 Sep;46(5):350-5.

(44) Christensen M. Noise levels in a general intensive care unit: a descriptive study. Nurs Crit Care 2007 Jul;12(4):188-97.

(45) Van RB, Elseviers MM, Van DW, Fromont V, Jorens PG. The effect of earplugs during the night on the onset of delirium and sleep perception: a randomized controlled trial in intensive care patients. Crit Care 2012 May 4;16(3):R73.

(46) Maben J, Griffiths P, Penfold C, Simon M, Anderson JE, Robert G, et al. One size fits all? Mixed methods evaluation of the impact of 100% single-room accommodation on staff and patient experience, safety and costs. BMJ Qual Saf 2016 Apr;25(4):241-56.

(47) Carthey J. Reinterpreting the Hospital Corridor: "Wasted Space" or Essential for Quality Multidisciplinary Clinical Care? HERD: Health Environments Research & Design Journal 2008 Oct 1;2(1):17-29.

(48) Westbrook JI, Woods A, Rob MI, Dunsmuir WTM, Day RO. Association of Interruptions With an Increased Risk and Severity of Medication Administration Errors. Arch Intern Med 2010 Apr 26;170(8):683-90.

(49) Trbovich P, Prakash V, Stewart J, Trip K, Savage P. Interruptions During the Delivery of High-Risk Medications. J Nurs Adm 2010;40(5):211-8.

(50) Anthony K, Wiencek C, Bauer C, Daly B, Anthony MK. No Interruptions Please: Impact of a No Interruption Zone on Medication Safety in Intensive Care Units. Crit Care Nurse 2010 Jan 12;30(3):21-9.

(51) Hohenhaus S.M., Powell S.M. Distractions and Interruptions: Development of a Healthcare Sterile Cockpit. Newborn and Infant Nursig Reviews 2008;DOI: 10.1053/j.nainr.2008.03.012.

(52) Colligan L, Guerlain S, Steck SE, Hoke TR. Designing for distractions: a human factors approach to decreasing interruptions at a centralised medication station. BMJ Quality & Safety 2012 Nov 1;21(11):939-47.

(53) Huckels-Baumgart S, Baumgart A, Buschmann U, Schupfer G, Manser T. Separate Medication Preparation Rooms Reduce Interruptions and Medication Errors in the Hospital Setting: A Prospective Observational Study. J Patient Saf 2016 Dec 21.

(54) Xiao Y, Schenkel S, Faraj S, Mackenzie CF, Moss J. What whiteboards in a trauma center operating suite can teach us about emergency department communication. Ann Emerg Med 2007 Oct;50(4):387-95.

(55) Dall'Oglio I, Fiori M, Di Ciommo V, Tiozzo E, Mascolo R, Bianchi N, et al. Effectiveness of an improvement programme to prevent interruptions during medication administration in a paediatric hospital: a preintervention - postintervention study. BMJ Open 2017 Jan 1;7(1).

(56) Colligan L, Guerlain S, Steck SE, Hoke TR. Designing for distractions: a human factors approach to decreasing interruptions at a centralised medication station. BMJ Quality & Safety 2012 Aug 14.

(57) Aktionsbündnis Patientensicherheit. Hilfestellung zur Umstellung von Luer-Verbindern auf neue verwechslungssichere Verbinder. Berlin: Aktionsbündnis Patientensicherheit; 2016 Dec 1.

(58) U.S.Food&Drug Administration. Examples of Medical Device Misconnections. 10-12-2016.

(59) Anderson O, Davey G, West J. Designing Out Medical Error. London: Redlin Print Ltd; 2011.

(60) Yu A., Flott K., Chainani N., Fontana G., Darzi A. Patient Safety 2030. London, UK: NIHR. Imperial Patient Safety Translational Research Centre; 2016.

(61) Pittet D, Hugonnet S, Harbarth S, Mourouga P, Sauvan V, Touveneau S, et al. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. The Lancet 2000 Oct 14;356(9238):1307-12.

(62) Thaler H.R., Sunstein C.R. Nudge: Wie man kluge Entscheidungen anstösst. 6. Edition 2016 ed. Berlin: Ullstein BuchverlagGmbH; 2011.

(63) Hansen PG. The Definition of Nudge and Libertarian Paternalism: Does the Hand Fit the Glove? EJRR 1 2016;(1):1-20.

(64) King D, Thompson P, Darzi A. Enhancing health and wellbeing through 'behavioural design'. J R Soc Med 2014 Sep;107(9):336-7.

(65) Bourdeaux CP, Davies KJ, Thomas MJC, Bewley JS, Gould TH. Using 'nudge' principles for order set design: a before and after evaluation of an electronic prescribing template in critical care. BMJ Quality & Safety 2013 Nov 26.

(66) Bourdeaux CP, Thomas MJ, Gould TH, Malhotra G, Jarvstad A, Jones T, et al. Increasing compliance with low tidal volume ventilation in the ICU with two nudge-based interventions: evaluation through intervention time-series analyses. BMJ Open 2016 May 26;6(5):e010129.

(67) Hansen P.G. iNudgeyou does health nudge experiment on buffet arrangement. 11-2-2013.

(68) Birnbach DJ, Nevo I, Scheinman SR, Fitzpatrick M, Shekhter I, Lombard JL. Patient safety begins with proper planning: a quantitative method to improve hospital design. Qual Saf Health Care 2010 Oct 1;19(5):462-5.

(69) de Korne DF, van Wijngaarden JDH, van Rooij J, Wauben LSGL, Hiddema UF, Klazinga NS. Safety by design: effects of operating room floor marking on the position of surgical devices to promote clean air flow compliance and minimise infection risks. BMJ Quality & Safety 2012 Sep 1;21(9):746-52.

(70) Züllig S, Mascherek A. Sicherheit bei Blasenkathetern. Empfehlungen im Rahmen des nationalen Pilotprogramms progress! Sicherheit bei Blasenkathetern. Zürich: 2016.

(71) Birnbach DJ, Rosen LF, Fitzpatrick M, Arheart KL, Munoz-Price LS. An evaluation of hand hygiene in an intensive care unit: Are visitors a potential vector for pathogens? Journal of Infection and Public Health(0).

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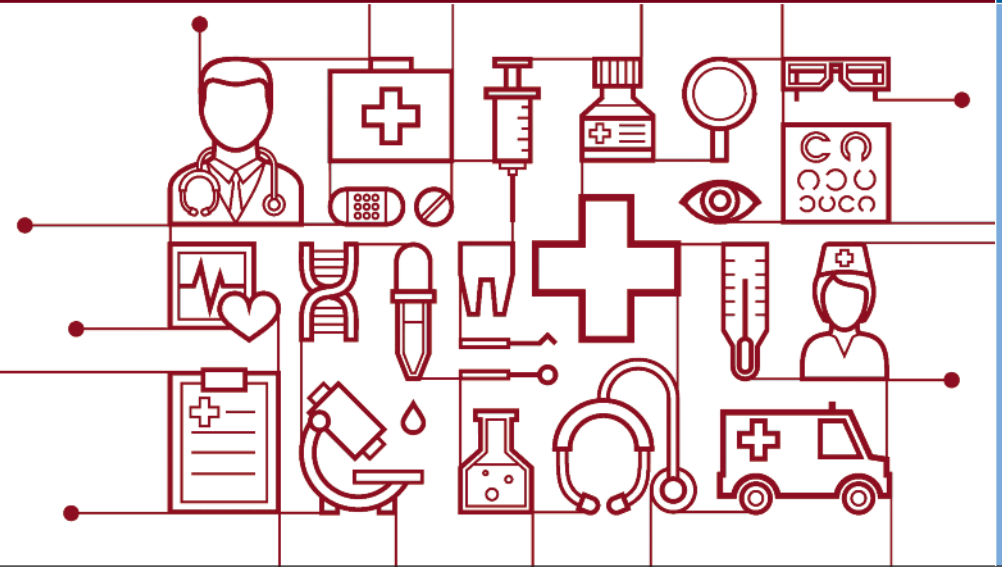

Foundation for Patient Safety
Office and contact
Asylstrasse 77, CH-8032 Zurich
Phone +41 (0)43 244 14 80
Fax +41 (0)43 244 14 81
www.patientensicherheit.ch
info@patientensicherheit.ch

Foundation headquarters
c/o Swiss Academy of Medical Sciences, Basel
Petersplatz 13, CH-4051 Basel

patientensicherheit schweiz
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