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PhD Thesis

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In the guise of safety: The cultural-cognitive ecosystem of medication errors and patient safety

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by

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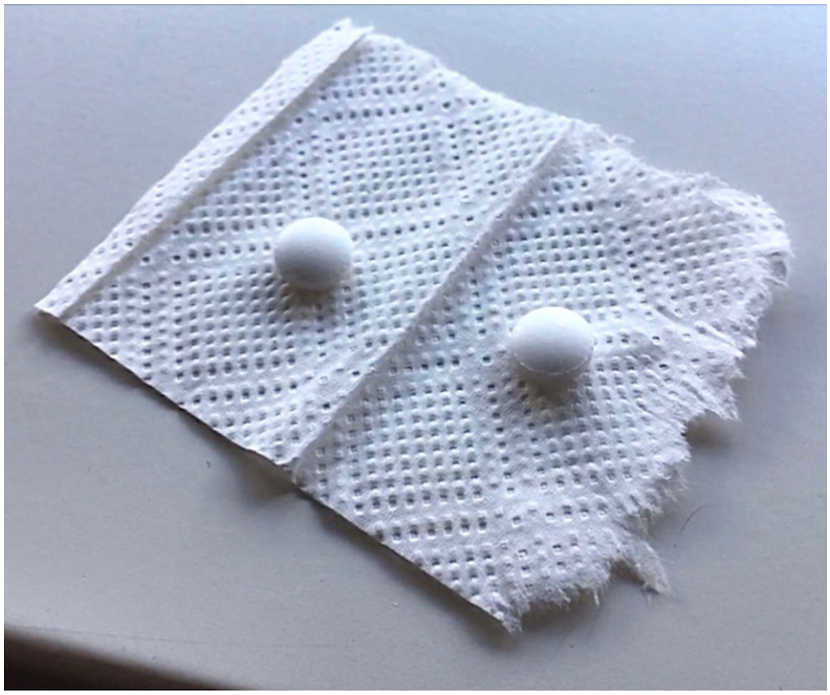


Chapter 1 *Introduction*

> A mistake follows an act. It identifies an act in its completion. It names it. An act, however, is not a mistake; it becomes mistaken. Seen from the inside of action, from the point of view of an actor, an act often becomes mistaken only late in its development. (…) We take the wrong path not in time, but in retrospect.
>
> Paget (2004, 45)

> Hindsight bias leads us to see only those forks in the road that practitioners decided to take - we see "the view from one side of a fork in the road, looking back" (Lubar, 1993, 1168). This view is fundamentally flawed because it does not reflect the situation confronting the practitioners at the scene. The challenge we face as evaluators of human performance is to reconstruct what the view was like or would have been like had we stood on the same road.
>
> Cook and Woods (1994, 305)

1.1 Beyond taken-for-granted patient risk

Take a look at the two pills in figure 1. Can you tell if they are identical? The pill on the left became contaminated when it was accidentally dropped to the hospital floor by a patient. A nurse, by the name of Ryan, has tried to identify the dropped pill and substitute it with the new replacement pill on the right. The two pills look similar, but are they the same? Has Ryan found the correct medicine, or does this become a harmful medication error when his patient is given the replacement pill?

This example comes from the ethnographic video data in Article B in Part II of this thesis and illustrates how difficult it is to be certain that patients are given the correct medicine. When a pill is accidentally dropped to the hospital floor, for whatever reason, it should not be given to the patient because it could be contaminated. Nurses thus have to make a choice: throw out the potentially contaminated pill, so the patient does not get their medication, or attempt to find a substitute. The choice is easy if the dropped pill is easily recognized, if the patient is only given a few pills, or if the pill is less significant such as vitamins. The choice is harder if the dropped pill looks like every other pill, like the

generic-looking pill in figure 1, or if it is one among many other pills. Then a replacement pill can be hard to find and potentially hazardous if the patient is given a wrong replacement. So, what does Ryan do? Does he throw away and forget about the pill at the peril of the patient? Or does he spend valuable time, running the risk of giving the patient the wrong medication? There is no obvious choice. This is *Ryan's dilemma* although most hospital nurses have been in similar situations when administering medicine.

Ryan's dilemma is akin to the well-known pill-dilemma in *The Matrix*. In this 1999 film, the computer programmer Anderson discovers that the world is not real but a complex computer simulation. Upon his shocking discovery, he is given the choice between a blue and a red pill. If Anderson chooses the blue pill, he forgets the whole thing and goes back to living his old life in ignorant bliss. If he chooses the red pill, he will become informed about the true, dangerous world behind the simulation. The nurse Ryan must make a similar choice albeit with less Hollywood drama. On the one hand, Ryan can throw out the contaminated pill that was dropped to the floor and blissfully ignore the whole affair. This is his "blue pill"-option, but it leaves the patient without one of his pills which can be dangerous because the patient now lacks a prescribed medication. Alternatively, Ryan can take up the challenge and find a replacement pill. This is Ryan's "red pill"-option. It also comes with risks since it could lead to a double adverse event of the patient getting both a wrong pill and still lacking the correct pill. Like in the movie, Ryan must choose between living in blissful myth or harsh reality, but both options come with increased danger.

Figure 1: A contaminated pill and an uncontaminated replacement (Article B)

Caught between two bad options, imagine if we could demand ”I want a third pill!”, preferably in the same thick Central European accent as Slovenian philosopher Slavoj Žižek does in his analysis of *The Matrix* (Fiennes, 2006). For Žižek, a hidden option exists in the form of a third pill. Instead of choosing between a blue and a red pill, between reality and myth, the metaphorical third pill reveals how *reality itself is structured as myth*. It allows us to see the subjective ideas through which we grasp our material environment. The third pill thus cancels the sense of urgency that the blue and red pill presents, which is why Žižek calls it *the analyst's choice*. Why do we have to accept the risks involved in Ryan's dilemma? Instead, we can insist on analyzing how it has become the norm that nurses such as Ryan, and their patients, are frequently exposed to the sharp end of the healthcare system in the first place (i.e., to situations where it can go badly wrong). How do nurses end up in a position where generic pills look so similar? Why do patients sometimes drop pills to the floor? Why does Ryan have to choose between two dangers? Taking the third pill means asking these types of questions. It means insisting that taken-for-granted patient risks do not represent a "natural state" of healthcare. Instead, *cultural* and *organizational* demands have transferred risks to operating units such as patient wards – that is, a kind of myth has come to structure the reality in hospitals.

While neither Anderson nor Ryan were offered the analyst's choice, 'the third pill' is a metaphor for this thesis. The pill does not exist, but this thesis simulates its analytic effect with careful investigations into the cultural-cognitive ecosystem of affordances and constraints on medicine administration in hospitals, the ecosystem that causes widespread medication errors to occur and persist. In this thesis, I show how existing research methods from the humanities and cognitive science can be integrated in a novel way to understand the organizational ecosystem and taken-for-granted risks in relation to medication errors. Furthermore, I show how an integration of methods can be directly applied in an organizational intervention towards reducing medication errors in Danish hospitals, in collaboration with nurses and doctors themselves. The thesis is thus both a contribution to safety science from a humanities perspective and a direct attempt at supporting hospital patient safety.

1.2 Medication errors – a short safety science examination

Medication errors are mistakes, accidents, and near misses that are primarily referred to as *medication adverse events* in Danish healthcare. Medication adverse events take many forms in hospital practice, for example, wrong doses, wrong drugs prescribed or delivered, known allergies missed, wrong timing or bodily route, missed doses, with dosing errors being the most common (Pham et al., 2012). These types of errors are very common in hospitals and are mainly associated with problems of human factors and social organizing (Dekker, 2015; Garrouste-Orgeas et al., 2012; Koetsier, Boer, & Loer, 2011; Kohn, Corrigan, & Donaldson, 2000; Rall, Gaba, Howard, & Dieckmann, 2010; Reader, Flin, Lauche, & Cuthbertson, 2006; Schaefer, Helmreich, & Scheidegger, 1994). According to the World Health Organization (WHO, 2016, 5) "medication errors are a global issue" with high rates of error in most healthcare systems, causing "considerable harm" with "significant health and economic consequences, including the increased use of health services, preventable medication-related hospital admissions and death". Research also shows that not only do medication errors victimize patients, but they also elicit significant psychological traumas in healthcare professionals involved (Sirriyeh, Lawton, Gardner, & Armitage, 2010; Winning et al., 2018). It creates a spill-over effect where other patients and colleagues of traumatized healthcare professionals are also affected (Seys et al., 2012). Hospital organizations thus require extensive second and third victim support programs for affected nurses and other healthcare professionals (Baas et al., 2018; Chan, Khong, & Wang, 2017; Schrøder, Janssens, & Hvidt, 2021). Currently, though, there is a "gap between the second victim's need for organizational support and the organizational support provide" (Ullström, Andreen Sachs, Hansson, Øvretveit, & Brommels, 2014). In other words, the problem of medication errors is a complex and widespread problem that extends throughout the healthcare system and affects everybody here.

Most errors relating to medicine primarily stem from problems of human factors, also known as healthcare professionals' non-technical skills, such as problems of leadership, communication, coordination, and teamwork (Flin, Glavin, Maran, & Patey, 2012). Human factors skills are different from technical skills, such as the ability to perform a medical procedure. In research, the field is known as *human factors* and refers to the behavioral, psychological, cognitive, social, and organizational dimensions of work with a

focus on how to design work so that humans are likely to commit fewer mistakes (Bridger, 2018). However, it is important to clarify why communication and coordination have become key skills for healthcare professionals. The reason is that healthcare professionals need to adapt constantly to novel situations in their work. Whenever a new patient arrives, a new situation of uncertainties and unknowns presents itself along with a constantly growing arsenal of therapy options and care technologies. As Drucker (2002) suggests, "healthcare institutions are complex, barely manageable places (...) Large healthcare institutions may be the most complex organizations in human history". In the complex hospital work environment, harmful errors often do not stem from the easily recognizable sudden malpractices or lapses, that human factors researchers have identified. Instead, errors are characterized by "periods of gradually increasing (but essentially unrecognised) risk, known originally in man-made disaster theory as the incubation period" (Dekker & Pruchnicki, 2014, 534). Often, work to improve safety and reduce error in hospitals does not match the insight that errors are slowly incubated in organizational cultures over long periods. Organizational researchers have found that organizations often react to repeated failure with more rules and regulations. Organizations rarely try to understand and learn from errors by fostering a learning culture sensitive to the complexity of errors and the early signs of an incubating error waiting to happen (Weick & Sutcliffe, 2015).

The problem is also prevalent in the Danish healthcare context of this project, where, "there is a need for other methods and approaches, which can reflect this complexity and focus on the future prospective prevention" (Viskum, Granhof, Pedersen, & Stæhr, 2011, 2554). In the Danish context, medication errors are one of the areas where adverse events are most commonly reported (Center for Kvalitet, 2016). In both the administrative Region of Southern Denmark and Danish hospitals in general, the number of reported adverse events has been increasing over many years and has stabilized at a high level (Center for Kvalitet, 2015; Dansk Patientsikkerhedsdatabase, 2005, 2016; Styrelsen for Patientsikkerhed, 2016). The Region of Southern Denmark, where this research project is situated, is continually working to reduce adverse events on all levels (Center for Kvalitet, 2015; Styrelsen for Patientsikkerhed, 2004). Also, the patient safety strategy of the Region of Southern Denmark targets specifically the reduction of medicine administration adverse events (Region Syddanmark, 2016).

So, medications errors are real and harmful. But the effects of medication error are only the last step in a chain of events, conditioned by organizational structures and perceptions in which errors can become incubated over a long period and make the system slowly "drift" towards failure (Dekker, 2011). In this process, interaction patterns undergo "subtle changes" and actions begin to escape the original intentions as work unfolded in time "generate a series of emerging cues" that is the early warnings of incubated error (Weick & Sutcliffe, 2015, 45). Ryan's dilemma above is an example of a cue of a potential medication error. While Ryan did find a replacement pill, the question is if such instances are paid attention to and registered as a cue of incoming failure or if the inherent danger is normalized and trivialized.

In healthcare, it is rare to see safety perceived as a culture of allocating attention towards emerging error cues. Instead, medication errors and near misses are often seen through the lens of individual nurse or doctors' *compliance* with guidelines. In this style of thinking, safety becomes the "absence of error" (Hollnagel, Wears, & Braithwaite, 2015); error is relegated to an undesired result to be avoided rather than the skillful action of adapting to changing circumstances while being aware and sensitive to what problem might come up next. In this way, the organizational perceptions of medication errors, the attention that healthcare organizations incentivize and allocate towards emerging failure, determines how the organization responds to errors. Specifically, reactive attention to errors as undesirable incompliance is always 'too late' because errors are only identified by their results and not their early cues. Errors are manifest, but their emergence depends on how healthcare professionals perceive and react to failure and failure cues. The problems of reactive attention towards error in healthcare have been described by Hollnagel (2014, 2018). He calls this approach to error a *Safety-I* paradigm and contrasts it with a proactive *Safety-II* paradigm. In a Safety-II approach, the focus is not on reacting to errors as negative events. Instead, the focus is on daily, successful action and *the corridor of normal performance*, between occasional overperformance and underperformance (Hollnagel, 2014). It is a change of focus from trying to have 'as few things as possible go wrong' to having 'as many things as possible go right'. Safety engineer Leveson (2020, 105) agrees with Hollnagel that healthcare has been one of "the least successful fields in reducing accidents". Still, she suggests that Hollnagel neglects the advancements that have

happened in safety science over the last century by fitting it all in the two categories of Safety-I and Safety-II. Leveson argues that, while Safety-II is a step in the right direction, increased healthcare safety will not follow from turning from a reactive to a proactive approach. In fact, hospitals already do take proactive precautions, she argues. Rather, the problem is that both Safety-I and Safety-II "concentrates almost entirely on the human operator" (Leveson, 2020, 104). Instead, healthcare institutions need to integrate a systems approach to safety:

> One limitation of the current approaches in healthcare and hospital safety is that they lack a holistic, systems standpoint, and the attempts to improve safety, while sincere, have been largely piecemeal and disjointed. Like the proverbial blind men and the elephant, each is focused on one part of the "elephant" but misses the other parts. Too much emphasis and responsibility has been placed on individual people, such as doctors and nurses, who have only limited control over the operations of the hospital and the healthcare system as a whole. A more comprehensive approach could be achieved by using systems thinking (…) (Leveson, 2020, 26)

Leveson calls such a holistic approach *Safety-III*. It involves taking into account both human and technological points of failure, with a focus on engineering hospital environments that works for both.

While Leveson's reading and correction of Hollnagel are highly instructive from a safety science perspective, there is a crucial difference in their approach. Hollnagel is a social scientist and emphasizes that Safety-I and II should be thought of as psychological and phenomenological (i.e., experiential) ways of coping with system complexity for healthcare professionals (Hollnagel et al., 2015, 17). As a safety engineer, Leveson, on the other hand, is not overly concerned with psychological experience and focuses instead on cognitive systems (i.e., how people get things done together). While Leveson identifies how socio-technical interaction can become a blind spot in a human-focused Safety-II paradigm, her approach creates a blind spot towards the shift in psychological attention that Safety-II implies (from a reactive to a proactive mindset). Leveson's (2020, 104) angle is evident in phrases like, "everyone does, of course, investigate accidents to learn from them—they would be foolish not to do so." Such sure-sounding statements hide the actual experiential reasons for human action by categorizing some of it as *foolish*. From my

observations in hospitals, there are at least three problems with Leveson's assumption that humans naturally investigate errors: firstly, it is taken for granted that errors are obvious and directly identifiable to human senses. In my experience, errors often go unnoticed until they result in harm. Secondly, it assumes that humans do not act in foolish ways. I have found that healthcare professionals can have good reasons for acting in ways that are considered foolish in retrospect – things look different inside action with limited information than afterwards. And thirdly, it fosters an attitude that is uninterested in the real reasons for human action, because we have already labeled some behavior as *foolish*. Again, what seems a foolish reaction to error (e.g., not investigating errors) might not have seemed so foolish at the time of action. This point is emphasized by other researchers of healthcare error and safety (e.g., Cook & Woods, 1994; Paget, 2004).

The blind spot towards actual human experience extends to how Leveson (2020, 33) thinks organizational systems operate: "The first thing that happens in creating any system is that the designers and stakeholders agree on the goals for the system". Such an approach has long been criticized by proponents of *dynamical systems* theory. As Thompson (2007, 38-39) explains, "a dynamic system is one that changes over time". Thus, the initial conditions and agreements on the goals of the system change through interactions over time. From the perspective of dynamical systems theory, "systems need to be seen as sources of their own activity, specifying their own domains of interaction, not as transducers or functions for converting instructions into output" (Thompson, 2007, 46). In other words, system autonomy must be recognized, and in hospitals action includes the local ideas that nurses and doctors have for doing what they are doing, foolish or not. The sensitivity to people's reasons for action is what Hollnagel is getting at by arguing that we should switch from thinking about humans as "liabilities" under a Safety-I paradigm to humans as "a resource necessary for system flexibility and resilience" under Safety-II (Hollnagel, 2014). Hollnagel acknowledges the human capacity to contribute to and change a system over time. In Leveson's view, it works the other way around. For her, the system always comes first: "The system must be designed to allow humans to be flexible and resilient" (Leveson, 2020, 28). In this way, the two researchers take opposite views on the origins of action within a system. To put it metaphorically, Hollnagel prioritizes how autonomous

interaction changes systems from 'the inside', while Leveson prioritizes designing initial conditions from 'the outside' and hereby prevent negative outcomes.

In summary, Hollnagel and Leveson add important perspectives to how we should think of medication errors in healthcare with the concepts of Safety-I, Safety-II, and Safety-III. Specifically, Hollnagel points to a dynamic shift in human attention, from focusing on adverse outcomes to everyday performance that can modulate the internal dynamics of the healthcare system. Leveson points to an ecosystemic perspective where a more deliberate effort is put into designing a healthcare system that can allow for flexible behavior without causing danger. Although Hollnagel and Leveson does not agree on the sources of action within a system, their discussion is illuminating of safety problems in healthcare. From the debate, three gaps in current healthcare safety can be identified:

The first gap is the attention gap to which Hollnagel points. A specific attention style means that some events come to be perceived as mistakes and some do not. In a reactive style of thinking, medication errors are often thought of as 'fixable' problems, but this is a specific framing of error that can hide factors that go beyond immediate fixing, such as interpersonal, cultural, and organizational factors. This gap directs this thesis towards taking seriously the experiences of healthcare professionals and the cultural perceptions that surround and influence the healthcare institution. In other words, the gap impels me to investigate how some errors come to *appear* as errors, through cultural ways of allocating attention.

The second gap is the systems thinking gap that Leveson points to, that is understanding how medication errors extend beyond individual medicine administration skills and into environmental factors. In healthcare, medication safety is often thought of as a local exercise and is not being integrated with the larger considerations of system-wide safety. The problem requires this thesis to take the wider distribution and ecosystems of medication error seriously, that is, analyzing errors as both local and systemic action.

The third gap is understanding the role of nurses and doctors themselves. Combining Hollnagel and Leveson's proposals, it is still left to be understood how healthcare professionals can be supported in efforts to reduce medication errors that emerge across the organizational ecosystem. Nurses and doctors themselves feel responsible for safe

medicine administration and must be supported, even if medication errors stem from ecosystemic hazards.

The gaps impel this thesis to take seriously the opinions, experiences, and practices of healthcare professionals. This thesis thus positions itself within a broader safety science discussion of how to think about the relationship between humans and systems, and where errors and safety originate in the relationship between the two. The thesis integrates both human and systemic perspectives by analyzing cultural perceptions of error as well as analyzing how actual medication errors emerge in hospitals. In this spirit, Leveson's (2020, 105) conception of Safety-III as "designing the system to prevent and control hazards" can be reformulated to 'designing the system to prevent and control hazards *while taking into account the experience and practices of healthcare professionals themselves*'. In this way, Hollnagel's focus on assessing and changing the perceptions of human operators is retained, while also adopting an ecosystemic approach that allows a holistic understanding of how medication errors emerge.

1.3 Approaching medication errors

When I set out to investigate medication errors, the original intention was to understand how in situ team training could impact medication practices in hospitals. I wanted to understand if local, simulation-based team training in the actual ward has the potential to reduce error. This approach was an alternative to predominant ways of addressing medication errors through 'general' approaches such as formal teaching (documented in Article C), the dissemination of medication guidelines, and implementation of behavioral nudges (documented in articles B & D), all methods that do not take into account the in situ circumstances and local differences of local wards and clinical specialties. As my research proceeded in close collaboration with health professionals, I came to realize that my framing of medication errors presupposed a certain diagnosis of the problem. Although I had hypothesized that local training was an important supplement to general approaches, I had already adopted the predominant attitude about what can and cannot be done about medication errors in hospitals. I too had come to see medication errors as *fixable* through training and other local or general methods.

As I gradually had this realization, I had to take a step back and investigate this framing of error. How come medication errors are perceived as fixable problems, and how come other forms of safety are hard to imagine from inside the hospital? And is simulation-based training still a viable route to patient safety in the light of my meditations? This gradual change in my project meant that although I had already gathered an immense amount of ethnographic video data and conducted a great many simulation-based training courses, the thesis scope became larger than that. The project became as much an investigation into how safety is *perceived* in healthcare, as what can be achieved with in situ simulation training in specific wards. Therefore, this thesis is as much an interpretive investigation into the symbolic and imaginative structures of healthcare institutions as it is an exploration into the causes of medication error and how team training addresses the problem. The thesis is a dissection of error both as a perceived, cultural object and as a daily, cognitive problem-solving task. This integration points to the *cultural-cognitive ecosystem* of medication errors, with a concept from Hutchins (2014), and it has become the defining feature of this thesis.

It has continued to surprise me how inaccurate our cultural ideas of healthcare error appear to be (documented in Article A) when compared with actual interactivity in hospitals (documented in Article B). I had to change my own commonsensical ideas about medication errors as a result of gathering video data. See, most medication errors do *not* reflect our common sense of error as momentary lapses of individuals. Rather, healthcare error has been shown by Trasmundi (2020) to emerge not as isolated events, but in *error cycles* between conditions of the hospital environment and the capacity for anticipating environmental changes by healthcare teams. When healthcare professionals try to adapt to non-routine events they can become fixated on one thing instead of balancing changes in the environment with individual tasks, thus becoming unable to anticipate what comes next (Trasmundi, 2020, 219). Still, our common perceptions of error influence what we think can be done about them and which safety precautions should be implemented. Hospitals often engineer safety systems that are designed to strengthen the individual responsibility of nurses by trying to shield them from their co-workers, such as the implementation of *no interruption zones* in hospital medicine rooms (documented in articles B & D). Paradoxically, such responses to medication errors make possible completely new

types of errors when it becomes even harder for nurses to coordinate flexibly and anticipate changes together (e.g., a junior nurse might not speak up and receive help in a no interruption zone). In this way, there is a complex interplay of subjective expectations and objective realities when it comes to medication safety and error. I have come to believe that it is in this interplay between subjectivity and reality that we must look for possibilities of reducing medication errors for the benefit of both healthcare professionals and patients.

Subsequently, this thesis seeks to understand why certain ideas on medication errors are more widespread than others in our healthcare system. The thesis also experiments with the possibility of changing perceptions through simulation-based training in hospitals. The basic research interest of this thesis is *why medication errors are continually being perceived and addressed as a problem of incompliance with hospital guidelines when this approach has not produced significant results (i.e., still no enduring decrease in medication errors)?* This interest frames this thesis as primarily an interpretive project that seeks to understand how styles of making sense and allocating attention contribute to or neglect adverse outcomes, thus upholding the status quo with little or no reductions in medication errors. Consequently, this thesis asks the hard question of our healthcare system (and of the Danish healthcare system in particular): if medication failure has become a persisting part of healthcare practice, should we understand it as a feature of the current system rather than as a deviation? I argue that medication errors require an understanding of how the system operates and makes things happen, rather than a focus on what should *never* happen. In other words, this thesis argues that medication errors must be analyzed as if they are produced through hospital practices and interactions and not as an occasional byproduct of the work. This approach is aligned with human factors researchers that have begun using the concept *error production* instead of older ideas of error as *slipups* and *lapses* (Bridger, 2018, 570). It can be uncomfortable and requires determination to "actively seek out bad news" in an organization (Weick & Sutcliffe, 2015, 58) rather than letting bad news come to us. But that is the goal of this thesis; to seek out the bad news (emerging adverse events) that is sometimes incubated inside the good news (everyday performance).

The thesis is thus an inquiry into the processes in which understandings of error are generated in Danish hospital organizations, both through local, clinical practices and

through larger cultural and scientific trends that impact on our understanding of error. Consequently, I have investigated both macro-level cultural explanations that impact the common sense conceptualization of error and micro-level interactions in Danish hospitals, to see how concepts of error and near misses emerge and are handled in the daily medication administration. My aim is to understand how medication errors are enacted between perception and action, between local circumstances and larger cultural-cognitive ecosystems. Based on this dialectical, micro-macro exploration, the thesis also attempts a novel type of intervention aimed at reducing medication errors at hospitals in the Region of Southern Denmark. That is, an intervention based on the existing technology of simulation training and on an understanding of the phenomenology and cultural-cognitive complexity of medication errors.

1.4 Research questions and aim

As defined in the research protocol, the two research questions of the project are:

1. How can an empirically validated approach to the study of organizational ecology be developed by integrating cognitive, phenomenological, and organizational perspectives?

2. From the perspective of 'organizational ecology', how can qualitative knowledge on the paths towards reduction of medicine administration errors be developed through the organization of a non-technical skills training course for healthcare professionals?

Based on the project's positioning in both a practical Danish healthcare context and in (humanities-based) safety science, the project addresses both an empirical/practical and a theoretical/methodological problem concerning medication errors, although the two questions are connected. The research aim of the project is the development of a method capable of investigating the socio-technical, cultural, and cognitive ecosystem of medication errors. Further, the project aims at the application of this method to support increased

healthcare safety by applying this method to two hospitals in the Region of Southern Denmark. The project does not aim towards a reduction of medication errors, and the thesis does not attempt to measure a quantitative decrease in medication adverse events after the intervention. Instead, the interest is in developing (i) qualitative knowledge on how the hospitals handle medication errors from a cultural-cognitive ecosystem perspective and (ii) knowledge on how simulation-based training can support organizational development.

The project is thus an endeavor to move beyond attempts to directly 'fix' the problem of medication errors (a safety-I approach), since this approach has yet to produce significant results in hospitals. Instead, this project is a qualitative investigation that aims to *understand* how medication errors are currently being enacted between everyday cognitive problem-solving in hospital wards and experiential perceptions of error. Based on this new understanding of medication errors, the project attempts to convert this knowledge into a simulation-based training course for healthcare professionals in Danish hospitals.

1.5 Reading guide

The thesis consists of two parts. In the first part, four chapters summarize the research project. Second, the project includes four self-contained articles for publication in scientific journals. After these two parts, the reader also finds a thesis summary in English and Danish. It is the four research articles that comprise the scientific contribution of the thesis, with the preceding chapters tying their methods and results together. The four articles are in different stages of publication. The first and third article (articles A & C) has been submitted to scientific journals and are currently being considered for peer-review. The second article (Article B) is already published. It is included here in its published form, only with thesis pagination added. The fourth article (Article D) is a manuscript, not yet submitted for a journal. In the following, I will provide a brief overview of the thesis chapters that lead up to the four articles.

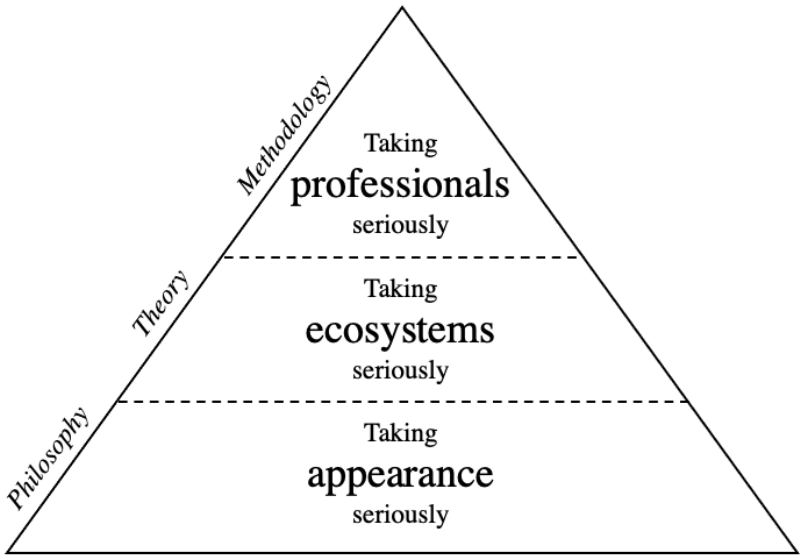
In Chapter 1 *Introduction* frequent medication errors in hospitals are problematized as harmful and costly, and the project is positioned within the contemporary safety science debate over what is the most relevant research paradigm for safety gaps in healthcare also known as the *Safety-I*, *Safety-II* and *Safety-III* paradigms. The chapter then presents the

approach towards medication error studies taken in this thesis which includes the combination of a focus on human experience and systems thinking. Finally, the research questions are presented.

Chapter 2 *Scientific approach* explains the philosophy, theories, and methodology with which the thesis addresses the research questions. It is outlined how phenomenological hermeneutics is used as a philosophical basis, distributed cognition as the theoretical framework, and action research as the methodological approach. The chapter does not explain in detail all the theoretical and methodological steps taken in the study, as these are covered in the journal articles in Part II. Instead, the chapter describes the overall framework of the research endeavor, which cannot be sufficiently explained in the limited format of the journal articles.

Chapter 3 *Study design* describes how the research project was planned, executed, and managed. The project is based on close collaboration with several actors and stakeholders from the hospitals of the Region of Southern Denmark, and the nature of this collaboration is described. Further, the specific methods of cognitive ethnography and phenomenological interviews are presented along with the qualitative data on which the project is based. The analytical procedures of hermeneutic interpretation, cognitive event analysis and systematic literature review are also described, along with the ethical considerations, such as funding, consent, and anonymity, that followed from doing an action research project with multiple project partners.

Chapter 4 *Results and discussion* summarizes the results from the four journal articles in Part II. A map of the results is presented, and the results are discussed in relation to the thesis's positioning in safety science, that is, up against the safety paradigms of Safety-I, II and III. Finally, the future implications and perspectives of the project are discussed. Here, the value of the methodology is assessed and considerations for future use and expansion in healthcare safety research are discussed.


Methodology
Theory
Philosophy
Taking
professionals
seriously
Taking
ecosystems
seriously
Taking
appearance
seriously

Chapter 2 *Scientific approach*

This chapter explains the philosophical, theoretical, and methodological considerations that constitute the scientific approach of the thesis. The approach addresses, in particular, the three gaps in current healthcare safety identified in section 1.2 of this thesis. In the first subsection below, it is described how the attention gap in healthcare safety (i.e., how errors come to *appear* as fixable) is addressed by adopting *phenomenological hermeneutics* as a philosophical starting point. The second subsection describes how the systems thinking gap is addressed through the theoretical approach of *distributed cognition*. In the third subsection, *action research* is presented as a way to address the gap in understanding the role and responsibilities of nurses and doctors themselves in the medication error ecosystem. Figure 2 illustrates how these three perspectives together constitute the overall scientific foundation of the thesis.

2.1 Taking appearance seriously: phenomenological hermeneutics

What do I mean when I say *appearance*, and what does it have to do with medication errors? In the introduction, I clarified that there is a gap in current healthcare safety that has to do with how errors are perceived, specifically the perception of medication errors as a fixable problem. I remarked on Hollnagel's (2018) proposal of a change in the psychological and cultural mindset in hospitals, from a reactive find-and-fix approach called Safety-I to a proactive focus on successful performances called Safety-II. It is a foundational assumption here that a change in psychological attention will produce other actions and thus other results in hospitals. In cognitive science, this assumption is often attributed to the *enactivist* approach to cognition. This school of cognitive research holds that action and perception are entangled and produce each other (Varela, Thompson, & Rosch, 2016). Enactivism was originally called *the hermeneutic approach* to cognition, owing to the philosophy of phenomenological hermeneutics from Husserl, Heidegger, and Merleau-Ponty (Thompson, 2007, 444n9). It was these thinkers who first argued that every thing is

perceived by a person, and that this inevitable connection between objects and subjects means that subjectivity must be the basis of objectivity. In other words, all knowledge and all action are based on a phenomenology, a way of interpreting the world. Consider this quote from Heidegger (2000, 107; translation slightly altered in accordance with that of Zimmerman, 1990, 224-5).

> Being means appearing. Appearing is not something subsequent that sometimes happens to being. Being presences as appearing.

It is a dense quotation – as with most Heidegger quotations. What he is pointing out is that there is no separation between being (something that *is* or *happens*) and appearance (how something is *perceived* in *consciousness*). This might sound like heresy to the classical metaphysical tradition in the west, where a basic assumption is that subjects can study objects from the outside. What Heidegger and other phenomenologists are pointing out, is that subjectivity and objectivity must be scrutinized together because they are forming each other. As Hubert Dreyfus explains, "reality can be revealed in many different ways and none is metaphysically basic (…) And just because we can get things right from one perspective, no single perspective is the right one" (Dreyfus, 1991, 280). Clearly, this philosophy contains a general critique of natural science, of which Husserl (1970) was very clear, as can be gathered from the title of his major work *The Crisis of the European Sciences and Transcendental Phenomenology*. Basically, phenomenologists argue, science works by adopting a 'tunnel vision' and digging out a specific perspective on reality. The

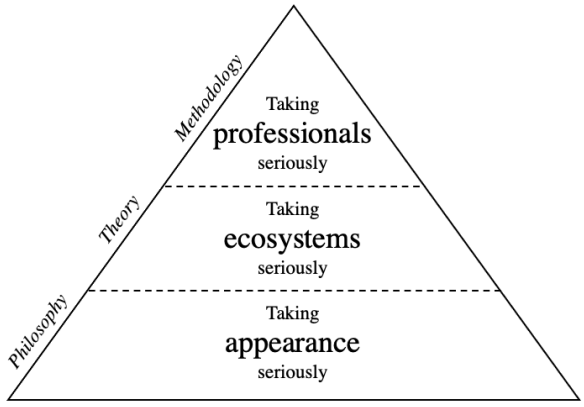


Figure 2: The scientific basis of the thesis

job of phenomenological hermeneutics is then to insist that subjects and objects are not originally separate entities and call attention to the original *dynamic unity of coming-to-being* as Bortoft (2012, 69) calls it. Later in this section, I explain how we can practically make such a shift in attention.

Before that, however, I want to discuss what phenomenological hermeneutics has to do with medication errors. This is perhaps best explained by looking into Paget's (1993, 2004) interpretation of medical work based on phenomenological and hermeneutic interviews with healthcare professionals. In her works, Paget shows how medical mistakes emerge in *unity* with medical practice:

> Most medical mistakes do not involve negligence. Many involve no dereliction in professional duty. They arise in the crucible of action as it unfolds. Many are errors in acts of judgement, in coming to understand the particular and special features of a patient's illness. They suggest no violation of professional standards. (Paget, 2004, 135)

What Paget discovers is that medical practice works by proposing diagnostical conjectures, based on symptoms and other clinical signs. The clinicians have to *act-as-if* the proposed diagnosis is true, although it might not be (Paget, 2004, 35) – a basic clinical methodology known as *differential diagnosis* (Newman & Kohn, 2020). Most medical mistakes, such as medication errors, does not arise from some unforeseen consequence but is the natural unfolding of making hypothesis with more or less scientific precision and effectively testing these hypotheses on patients (i.e., providing therapy that corresponds to the perceived diagnosis). We should think of this dynamic as mainly favorable argues Montgomery (2005, 3) in her book *How Doctors Think*. It is positive that clinicians draw on both their personal diagnostic experience and on scientific information when they exercise clinical judgment. A physician who would act only in accordance with science would eventually become passive, as data is never entirely conclusive:

> If medicine were practised as if it were a science, even a probabilistic science, my daughter's breast cancer might never have been diagnosed in time. At 28, she was quite literally off the charts, far too young, an unlikely patient who might have eluded the attention of anyone reasoning "scientifically" from general principles to her

> improbable case. Luckily, medicine is a practice that ignores the requirements of science in favor of patient care. (Montgomery, 2005, 84)

The practical judgment that healthcare professionals must balance with scientific knowledge extends to medication errors too. Here, it is the daily practice of nurses that do their best to administer the correct medicine to patients safely and effectively. We can now begin to see what appearance has to do with medication errors. We have to bring attention to what happenings clinicians experience as errors and which they do not. In which situations do healthcare professionals act-as-if a certain pill is the correct pill (which it might or might not be) and in which do they show doubt and hesitation. By insisting on going back into the *dynamic unity of coming-into-being* of medication errors and medical practice, we might get a sense of where error reductions can take place.

But how do we switch attention from error to the appearance of error? Here I draw especially on the book *Taking Appearance Seriously*, in which Bortoft (2012) connects phenomenological hermeneutics with Goethe's alternative, dynamic scientific method. Bortoft uses the metaphors *upstream* and *downstream* to indicate the shift in attention. Moving downstream means following the current of human experience, in which we naturally observe the products of consciousness, the experience itself. However, Bortoft argues that we can also pay attention to the formation of experience, rather than the experience itself. "This can perhaps be described most simply as 'stepping back' into where we are already. This means shifting focus of attention within experience away from what is experienced into the experiencing of it" (Bortoft, 2012, 17). Still, this is rather vague, I think. What does it mean to 'step back into where we are already'? Take the example of a person waving at you from across the street. On a commonsense, downstream view, we might reconstruct this situation by saying 'the person waved at me to say hi'. But moving upstream, we notice that this is not entirely how the situation was experienced. The gesture itself *is* the appearance of *meaning*, not meaning simply added to the apparent gesture (Bortoft, 2012). As Gadamer (1986, 79) explains: "What a gesture expresses is 'there' in the gesture itself. A gesture is something wholly corporeal and wholly mental the one and the same time. The gesture reveals no inner meaning behind itself". The same holds with any other gesture. A gesture of anger *is* the anger – we will not find the anger behind the

gesture. This insight requires us to formulate and write down our thoughts in a different manner since our language has developed to hide appearance:

> When our attention shifts upstream into what appears in its appearing, then it becomes awkward to say 'it appears' because the very form of this leads us to think of an 'it' which 'appears'. This encourages us to think of 'it' as being there already, and then appearing. But this gets it back to front, by imagining 'it' as if it had already appeared before it 'appears'! We would do better to say 'appears it'. This may be bad grammar, but it is better philosophically because now 'it' emerges *for the first time* in its appearing, and so this avoids the mistake of separating 'it' from 'appearing' (Bortoft, 2012, 95)

In this vein, instead of saying 'the person waved at me to say hi' we can say 'the person hi'ed waving at me' although this is also bad grammar, but closer to the experience of the situation. Ingold (2015, 134) uses the image of *wayfaring in a labyrinth* for such a way of paying attention. He describes how walking in a labyrinth is experienced different than a city for the first time. There is no logical or experiential basis for wayfaring in a labyrinth; all paths appear new all the time. Similarly, shifting upstream means that all experiences, although already experienced, must be retrodden as new. Varela (1991) uses a similar image of *laying down a path in walking* for such an upstream style of research. The point is that every action step forms our perception of the research subject, but it is not a discovery of a true path, it is only the path that we ourselves tread. In figure 2, I have illustrated the move towards an upstream way of approaching experience.

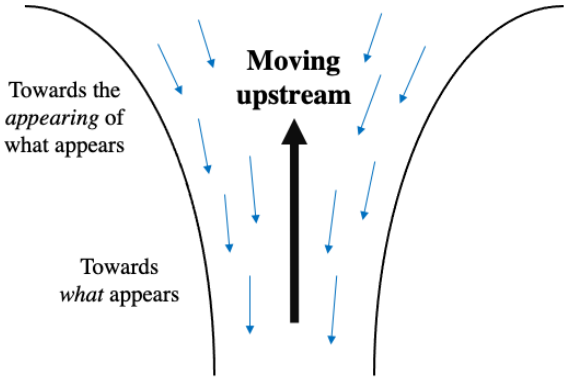


Figure 2: Moving upstream in conscious experience, focusing on the *appearing* of what appears, rather than only on *what* has appeared (illustration insipired by Bortoft, 1996)

For the purposes of this thesis moving upstream is primarily achieved in conversations with healthcare professionals about their experiences. It is also achieved by writing down my own experiences and trying to reflect on these from an upstream position. Such reflections are what Husserl (1987) called a *philosophical attitude* in contrast to a *natural attitude* – concepts that are similar to upstream and downstream. In the philosophical attitude we begin to peel away the normal givenness of an experience to us. An example of phenomenological writing is Van Manen's reflections of glancing at a clock.

> As I am writing this sentence, I glance at the clock on my desk. Almost bed time. I don't really see the face, dial, and hands of the clock. Rather I "see" where I am with my writing in the context of the evening. If someone were to ask me at that very instant what time it is as I direct my eyes back to my work, I would probably have to glance at the clock again. (van Manen, 2019, 922)

The clock dials appeared to Van Manen as 'almost bed time'. Only by taking a step back through his writing, into his own experience, he discovers how he did not perceive time *as time*, but as something else: as an experience of *writing*. In a similar manner, this thesis attempts to describe the experience and occurrence of medication errors from a perspective of philosophical attention, without any specific agenda, but from a perspective of curiosity towards my own experience of error, as well as the experience of healthcare professionals. Basically, the hermeneutic approach to medication errors means a fundamental shift in way of doing scientific research, that is, from studying errors as a *being* to studying a *formative doing* (Bortoft, 1996, 270).

2.2 Taking ecosystems seriously: distributed cognition

The second step in the scientific approach of this thesis is systems thinking, in line with the proposal of Leveson (2020). Here, I follow the basic principle from systemic psychology, that "Research should start from the determination of the results of behavior and lead to the necessary constituents of the living system determining the achievement of these results" (Järvilehto, 2009, 118). The idea is that humans leverage cognitive

systems in order to bring forth the results of their behavior. This is a functional view on cognition, in which the cognitive system is thought of as "a constellation of structures, some of them internal to the human actors, some external, involved in the performance of some invariant task" (Hutchins, 1995, 281). In other words, instead of focusing on the human perspective, the distributed cognition view instead looks at how tasks are executed by humans and their environment together. The distributed view on cognition holds that cognitive processes crisscross the boundaries of brains, bodies, artifacts, time, and culture (Hollan, Hutchins, & Kirsh, 2000), and it is thus different from the classical cognitivist conception of cognition in which the human is thought of more like a computer. Thus, for the classical cognitivist, "mental processes are carried out by the manipulation of symbolic representations in the brain" (Thompson, 2007, 5), but on the distributed view, the brain is only one part of a system that includes the body, the environment, the culture, etc.

From the perspective of phenomenological hermeneutics, taking a distributed view on a cognitive system starting from its results is a downstream way of doing research. Figure 3 visualizes how a distributed cognition view takes a downstream view of appearance, focusing on *what* has appeared – that is, looking back at experience. It is from the results of behavior that distributed cognition looks back to see what constrained this type of behavior in the first place. Rather than going back into experience and revealing its multiplicity in meaning and becoming, as when we are moving upstream, a downstream investigation focuses entirely on what has become, and the processes and experiences that lead to that specific result. This could for example be focusing on a medical near miss, as

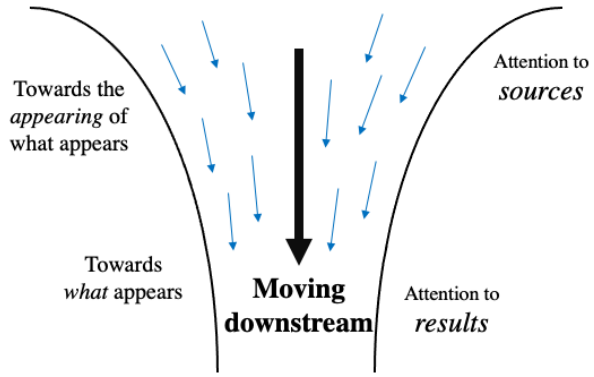


Figure 3: Moving downstream in conscious experience, focusing on what has appeared (illustration inspired by Bortoft, 1996; Scharmer, 2009)

demonstrated in Article B, and looking back to see how an error was averted through the collaboration of humans, artifacts, and technologies.

My study of medication errors from a systems approach is not only motivated by Leveson's identification of a system thinking gap in healthcare safety. My prior research had also shown the existence of this gap. Thus, Bing, Christiansen, and Lebahn (2015) investigated the problems of maintaining hand hygiene compliance in hospitals and concluded that:

> Good hand hygiene of healthcare staff (and patients) is the end goal, but it is only a tiny piece in this complex *ecosystem* that works with and is affected by the issue of hospital-acquired infections. Instead of forgetting all other stakeholders, the solutions of the future must be organised around a cross-organisational joint action (Bing et al., 2015, 175, my translation)

Problems of hand hygiene, and the hospital-acquired infections that follow, are complex due to human and cultural factors. This is similar to medication errors. Bing et al. (2015) found that only joint action across a vast organizational ecology could change the status quo of frequent adverse events. In Bing et al. (2015) the concept of the ecosystem is, however, only a metaphor for the complex system of hospital adverse events that include hospital-acquired infections and medication errors. This approach lacks the ecosystem-conceptualization found in for instance Trasmundi & Steffensen (2016) and Cowley (2014). These researchers take a distributed view of human behavior required for the analysis of the entire ecosystem. In this *ecological* school of humanities research, the ecosystem of humans is not a metaphor. According to Steffensen (2015b, 113), it refers to "the totality of the meshwork of interactions among organisms, and between organisms and their environment, the niche that comprises all the conditions of existence for this meshwork, as well as all the results of these interactions." He goes on to use the analogy of beavers to explain why some phenomena require an ecological view:

> To describe the dam-building practice of a beaver colony, one must consider the interactions amongst beavers, between beavers and other species (predators and flora), as well as the niche of the freshwater basin, branches, logs, etc., that allows for this practice, and that is affected by it. (Steffensen, 2015b, 113)

Similarly, to get at hospital-acquired infections or medication errors, one must adopt a framework that can account for the relationship between many different parts of the hospital organization, some material (such as technologies) and some immaterial (such as hierarchies). In the case of human ecology, what is unique is that interactions between individuals are *sense-saturated*, that is filled with symbols and meaning, that extend the interactions backward and even forward with past experiences, past histories, and future expectations (Steffensen, 2015a). Therefore, a description of the human ecology must also describe the meaning-making structures, that is, the interpretations enacted in interactions that animate and saturate the healthcare organization, as well as the outcomes of meaning-making.

So how can one describe cognition as distributed? On this view, cognition is not something that happens inside the brain of humans, but rather an interactive process of extension where cognitive functions can be extended throughout a social group, the environment, and cultural components (Hollan et al., 2000). A good example for understanding the framework of distributed cognition is a queue in a supermarket. In a queue, the place in line is not something that people have to remember themselves (that is, they do not have to rely on their brain for this function). Instead, the act of remembering your place in line is ingrained in the cultural exercise of going to the back of the queue and letting the line itself function as a memory device (Hutchins, 2014). Trasmundi (2020) has shown how such an ecological, distributed framework can explain the emergence of medical errors more comprehensively than other models of cognition used in healthcare, and my thesis builds on her insights by using cognitive ethnography for investigating the distributed cognition of medication errors. Just like in the supermarket queue, healthcare professionals rely extensively on cognitive-cultural artifacts when doing their work. In my thesis, the ecosystem analysis of healthcare errors thus supplement the hermeneutic interpretation of error experience and perception. Thus, this project does not stop at analyzing the cognitive functioning of the healthcare system, but rather the *cultural-cognitive ecology* of medication errors, using a concept from Hutchins (2014). Accordingly, this project takes both an upstream view, focusing on appearance and the sources of experience, as well as a downstream view, focusing on the results of cognitive systems working to achieve tasks.

2.3 Taking professionals seriously: action research

The third and final gap in healthcare safety is the question of how best to support healthcare professionals when medication errors emerge in ecosystems. Here, I mainly take inspiration from organizational action researchers Scharmer (2009), Senge (1990), and Schein (1985), and their MIT school of research known as *organizational learning* theory. Compared with the upstream thinking of hermeneutics and the downstream thinking of distributed cognition, I am using the concept of *midstream*, which Scharmer (2009, 64) added to Bortoft's hermeneutics, to describe how my action research approach relates to the other approaches described here. Moving midstream means paying attention to organizational processes that follow from experiential sources and lead to organizational results. This move is illustrated in figure 4.

The midstream approach focuses on organizational processes, which means that the thesis is based methodologically on an *action research* approach. Action research is basically the idea that generating knowledge on research subjects should involve participation of those subjects themselves (Bradbury, 2015). This basis means that the goals of nurses and doctors at Hospital Sønderjylland Aabenraa and Odense University Hospital, where this research project is situated, are reflected in the research aims of the project. Both Hospital Sønderjylland Aabenraa and Odense University Hospital are interested in a decrease of medication errors, which would reduce patient harm and financial costs. When data was gathered in the hospital organizations, it was analyzed along with healthcare professionals

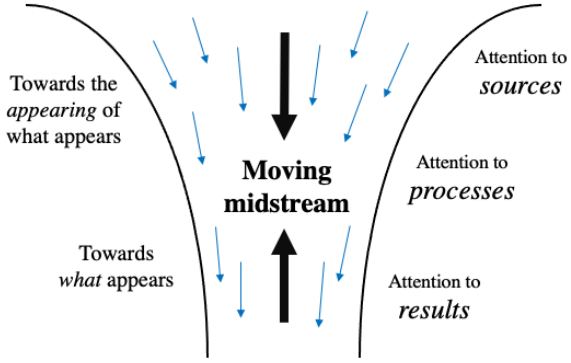


Figure 4: Moving midstream in conscious experience, focusing on processes (illustration inspired by Bortoft, 1996; Scharmer, 2009)

themselves. Data were also analyzed together at dialogue sessions with project partner and intensive care nurse Lotte Abildgren and the project supervisors, most of whom have a clinical background. The data and analysis are then considered to formulate new interpretations that are brought back and discussed again with professionals. The process leads to new considerations next time data is gathered in the hospital. In organizational research, this approach is called *interpretive* and *dialogical studies:*

> While theory may provide important sensitizing conceptions, it is not a device of classification nor tested in any simple and direct manner. The key conceptions and understandings must be worked out with the subjects under study. Research subjects can collaborate in displaying key features of their world. (Deetz, 1996, 202)

As a dialogical action research study, the goal of this thesis becomes to answer the research question through collaboration with healthcare professionals themselves, including writing scientific articles together. How this was achieved is described in detail in the next chapter.

Chapter 3 *Study design*

3.1 Partnership & collaborative setting

This thesis is based on cross-faculty and cross-institutional research collaboration. The PhD project is one half of a research collaboration called *SimLEARN*, with another ongoing PhD project making up the other half. While this project is situated at the humanities faculty, the sister project is situated in the health faculty. SimLEARN is supported by two hospitals in the Region of Southern Denmark, that is Hospital Sønderjylland Aabenraa and Odense University Hospital, and by the University of Southern Denmark (SDU). The project has received funding from all these three institutions. The goal of SimLEARN is to study how frequent adverse events in hospitals can be avoided using human factors training. With prior research showing that human factors are the source of most adverse events (Kohn et al., 2000), SimLEARN is an attempt to study the phenomenon through both a social science/humanities PhD project (this project) and a health science PhD project (project by qualified nurse Lotte Abildgren). See the two project partners in Figure 5. The two PhD projects have been developed in collaboration from the project beginnings in early 2017, with empirical data being gathered together and organizational interventions being done together. Further, the results are being reported in co-authored articles. Abildgren is the secondary author of the articles B & D in Part II. She is the primary author of Article C, with me being the second author of this article. The two PhD projects also share supervisors. Humanities professor Sune Vork Steffensen is the primary supervisor on this project, with nursing professor Lise Hounsgaard being the secondary supervisor. In Abildgren's project, it is the other way around, with Hounsgaard as primary and Steffensen as secondary supervisor. Furthermore, clinical professor Christian Backer Mogensen from Hospital Sønderjylland Aabenraa is also a secondary supervisor on both PhD projects. Clinical professor Palle Toft from Odense University Hospital is also a supervisor on Abildgren's project, showing the cross-institutional nature of the project. This thesis focuses specifically on medication errors from a humanities research perspective since this

Figure 5: This project was conceived and managed in collaboration with a second PhD project. Here, it is project partner Lotte Abildgren on the right and me on the left. In the middle is the high-fidelity simulation doll used for in situ training (not used in medicine room training).

is where a large share of harmful and costly adverse events happens. Abildgren's forthcoming thesis focus on team collaboration from a health science perspective since human factors have been identified as a primary source of error. While it makes sense to see this thesis in its context of the more extensive SimLEARN research setup, the thesis has also been written to comprise a self-contained research contribution.

3.2 Data gathering, analysis & reporting

The empirical data for the project was gathered at two departments at Hospital Sønderjylland Aabenraa and two departments at Odense University Hospital – all highly specialized wards with intensive care capabilities. The departments were selected based on a number of reported adverse events identified through the yearly report on adverse events from the administrative Region of Southern Denmark (Center for Kvalitet, 2016). The departments did not have significantly more or less adverse events than other departments in the region and were considered representative of most hospital departments with

acute care capabilities here. The chosen departments had reported between 0.2-1.4 yearly adverse events per employee in 2015. It is important to stress that the Danish adverse event reporting system is based on voluntary reporting with no sanctions, so many reported adverse events might not point to a particular issue at these departments. Instead, the numbers might reflect a departmental culture of reporting and reflection after adverse events, just like different departments differ in what severity of adverse events are reported and whether near-misses are also reported (Styrelsen for Patientsikkerhed, 2017). In any case, the reported adverse events showed that the selected departments were subject to frequent adverse events, as is the case with most hospital departments. Another selection consideration was that the two departments at each hospital were similar in their medical specialty which allowed for comparisons between hospitals.

Upon our reaching out, the management of the four departments indicated an interest in both our qualitative investigation into the emergence of error in their departments and the simulation-based training course intervention. Throughout all phases of the collaboration, it was stressed that participation from healthcare professionals, patients, and relatives was voluntary. All research subjects were informed about projects methods and goals and all participants signed a document of informed consent to participation and to our administration of personal their private data (video recordings). It was stressed that all research subjects could freely withdraw from the research project at any time including after the gathering of data. Informational material on project plans, aims, and methods were distributed to all participants and departments. At the time of publication, we have not received any requests for withdrawal from the project from any participants or departments. In this thesis, empirical data that feature healthcare professionals are blurred or anonymized, and all data that feature patients is anonymized. We elicited approvals from hospital management, The Regional Committees on Health Research Ethics for Southern Denmark (case number 20182000-140), and from all involved research subjects (i.e., healthcare professionals and patients) before research inquiries at departments. Subjects at the four departments that contributed to the project are blurred and patients are anonymized.

All in all, approximately 112 hours of video were recorded in the four hospital departments. 53,5 hours of recording were allotted before simulation training, 51 hours

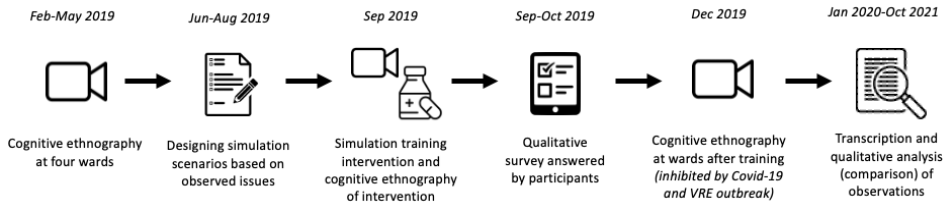


Figure 6: Study method steps (Article D)

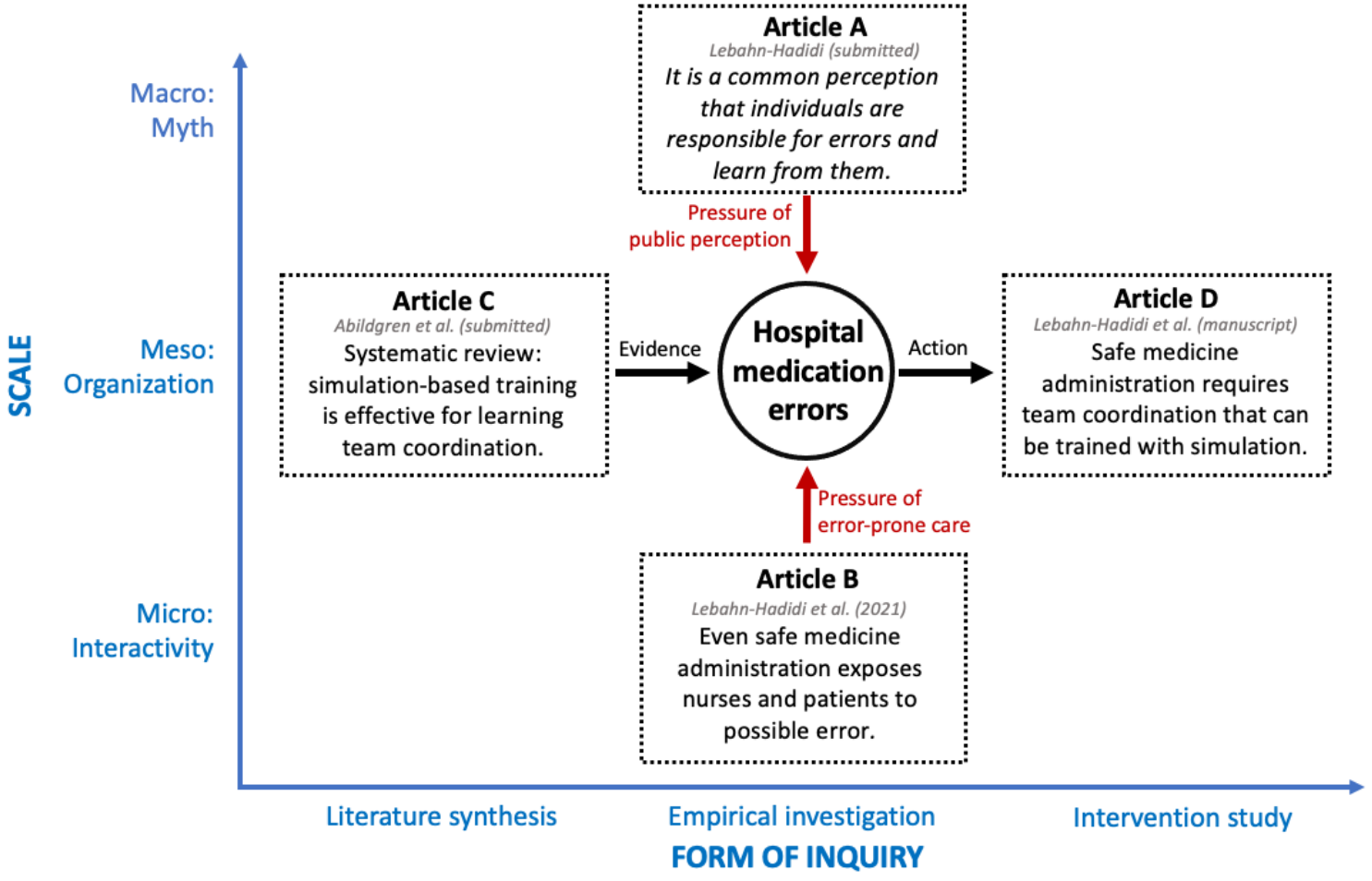
during training (training was recorded from three angles, 17 hours of training in total), and 7,5 hours after training (see articles B & D). Due to a breakout of Vancomycin-resistant Enterococcus at one hospital and later the Covid-19 pandemic, we were not able to gather video data after training to the same extent as before and during training. After the training intervention, participants were also sent a survey about their training experience (see Article D). Figure 6 visualizes the timeline of cognitive ethnography, simulation-based training, and a qualitative electronic survey in the project. Besides the video recordings in hospitals, the thesis also uses the popular medical television dramas as data for analysis.

The project uses a handful of qualitative methods for gathering and analyzing data:

- Cognitive ethnography (Ball & Ormerod, 2000, 2017; Trasmundi, 2020) with video cameras were used as the primary method for obtaining data in the hospital. Healthcare professionals were observed before, during and after an in situ simulation training intervention at all four wards (see articles B & D). Supplementary field notes were written during and after every ethnography session. Notes and observations were shared and discussed between Abildgren and me.
- A simulation training course was designed by Abildgren and me based on the ethnographic observations of what problems and issues were present in the wards. Simulation training has been shown to be an effective way of capturing team dynamics (Lavelle et al., 2020) and in this project is it coupled with observation both before and after the training. The combination of using both cognitive ethnography and simulation team training as research methods is a distinctive feature of the project. Video recordings were the primary method of gathering data, and the in situ simulation-based team training (Dieckmann, Sharara-Chami, & Ersdal, 2020; Dieckmann, Zeltner, & Helsø, 2016) with subsequent debriefings was also video recorded (see articles C & D).

- Phenomenological interviews (Høffding & Martiny, 2016) with nurses and doctors were also conducted during the cognitive ethnography (see Article B).
- A systematic literature review of the effectiveness of simulation-based training of human factors (see Article C). 19,767 scientific articles were reviewed using the AMSTAR 2 measurement criteria (Shea et al., 2017) and the review followed the PRISMA reporting standard (Page et al., 2021). The protocol was registered in the international PROSPERO register (Page, Shamseer, & Tricco, 2018) (see Article C).
- A hermeneutic, qualitative media analysis was used to interpret cultural representations of healthcare errors, specifically through an analysis of popular medical television dramas *Scrubs*, *Grey's Anatomy*, and *House* (see Article A). The television dramas where selected based on what television shows medical researchers most often include in their own studies of how healthcare procedures are communicated to the public.
- For analysis, the project uses hermeneutic interpretation (see articles A, B, and D) combined with Cognitive Event Analysis (Article B), and an enactive analysis combined with grounded theory (Article D).

After data gathering and analysis, the studies have also been reported and disseminated. Other than through publication in scientific journals, feedback and dissemination of the research results were planned at the participating departments and hospitals. However, it has not been possible to provide feedback of results to departments yet, due to the ongoing Covid-19 pandemic and nurse strikes.


Article A
Lebahn-Hadidi (submitted)
It is a common perception that individuals are responsible for errors and learn from them.
Pressure of public perception
Article C
Abildgren et al. (submitted)
Systematic review: simulation-based training is effective for learning team coordination.
Evidence
Hospital medication errors
Action
Article D
Lebahn-Hadidi et al. (manuscript)
Safe medicine administration requires team coordination that can be trained with simulation.
Pressure of error-prone care
Article B
Lebahn-Hadidi et al. (2021)
Even safe medicine administration exposes nurses and patients to possible error.
SCALE
Macro: Myth
Meso: Organization
Micro: Interactivity
Literature synthesis
Empirical investigation
Intervention study
FORM OF INQUIRY

Chapter 4 *Results & discussion*

There is a rule in film editing, known as the *Kuleshov effect*, which states that more meaning is generated from the interaction of two sequential shots than from what happens within a single shot. A similar effect must be considered when writing an article-based anthology. While each article in Part II comprises its own scientific contribution, the connection between the articles produces a larger, overall argument. The overall thesis argument is generated in the space between the articles in a type of "Kuleshovian 'creative geography'" (Leitch & Poague, 2011, 75), or what we could call a 'creative mapping' of the subject area of medication errors. The map of the thesis in figure 7 represents such a creative carving out of the research area – sketching out how approach and methods relate to the results. This map is, however, not a comprehensive map of the entire ecosystem of medication errors but rather an interpretation and a way to understand how individual people and constellations draw on the larger ecosystem when trying to accomplish tasks in their specific niche. It is not an aim of the project to draw a complete picture of the cultural-cognitive ecosystem of medication errors, but rather to sketch a situated map from which to draw conclusions (in the form of inferences/abductions) about the general workings of the ecosystem.

4.1 Summary of articles

As visualized in figure 7, the articles A and B in Part II are placed vertically at opposite scales. Article A, *The social contract of medical error: understanding adverse events in medical television dramas,* is an exploration of the cultural representations of medical errors in mass culture. The article provides an entry point to understanding how western cultures comprehend and deal with continuous service failure in one of our most essential institutions, that is hospitals. The article finds that medical researchers have not properly understood the representation of healthcare errors in popular culture. They tend to take a technical view of error and blame medical television dramas for not portraying correct technical procedures when representing doctors and nurses. However, medical researchers

miss the underlying message communicated in medical television dramas: that healthcare professionals should be learning, getting better, and taking more responsibility with every error. This message is comforting, but it is also an unrealistic message since most real errors are missed, not reflected on, and do not lead to learning in real healthcare institutions (see section 1.2). The messages communicated in mass media about errors thus represent a double-edged sword for hospitals: while trust might be retained in hospitals despite continuous medical failure, this trust is not based on how healthcare actually operates. It puts pressure on hospitals to signal learning and improvement. In other words, hospitals are required to show that they do something about errors and take responsibility. This is a problem, because research shows that most errors are not learned from and does not lead to improvements, creating a gap in expectations.

From this overall view of our cultural common sense of healthcare errors, Article B, *Integrating cognitive ethnography and phenomenology: rethinking the study of patient safety in healthcare organisations,* zooms in on a single error in a Danish hospital. The article explores the emergence of medical error at a micro-scale, in one specific hospital department and with one specific patient. It is shown how the nurse Ryan successfully locates a replacement pill after a patient accidentally dropped a pill to the floor. Although the interactions lead to a successful outcome, the patient gets his pill, the analysis shows

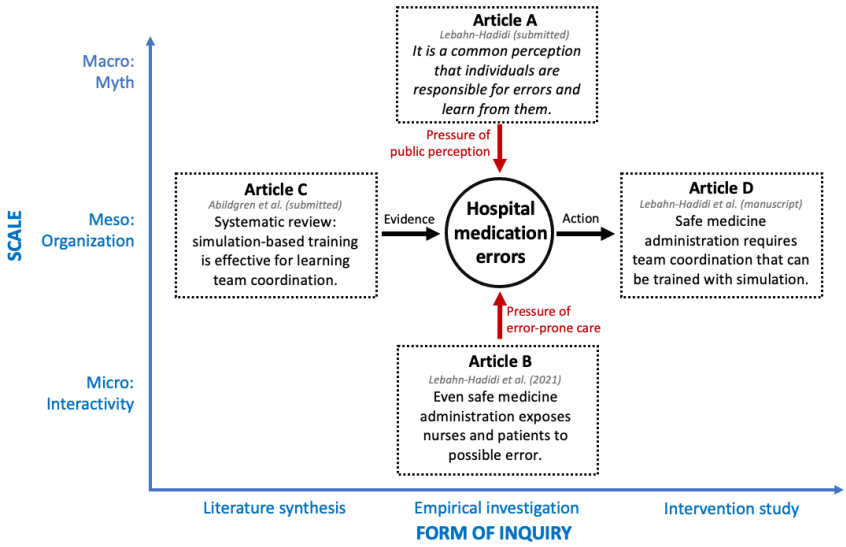


Figure 7: Map of the thesis with approaches and the results of the four comprised articles.

how the system becomes vulnerable in the process. Risk increases because of conflicting demands on Ryan and his colleagues, for example, to both collaborate and to not interrupt colleagues. It is concluded that even safe medication administration increases risk in other parts of the medication ecosystem at the ward. Medicine administration is an error-prone process, not because of slipups or lapses in work, but due to the inherently contradictory nature of the work process itself: due to organizational demands of efficiency and costs, nurses are sometimes put in positions where there are no good choices, only choices that lead to increased risk. On an organizational scale, medicine administration puts pressure on the hospital institution because it will, over time, produce mistakes due to the inherent risk produced in the process.

In summary, article A and B, describe two different pressures on the hospital organization. As visualized in Figure 7, one pressure comes from "above" (cultural expectations of hospitals) and one from "below" (the error-prone nature of daily medicine administration). The public expects healthcare error to lead to a better healthcare system over time and to be or become safer than it actually is, and error-prone medicine administration unavoidably produces error over time. The two pressures are opposite and will conceivably lead to a clash of expectations in the hospital organization and a potential crisis in the confidence in healthcare.

Next, articles C and D in Part II are placed horizontally in figure 7, both being located at an organizational meso scale. These two articles focus on what can be achieved with in situ simulation-based training of human factors in hospitals with regard to medication errors. In other words, the articles investigate if simulation-based team training can potentially address and relieve the pressures from "above" and "below" the organization. The goal of training is learning, so simulation has the potential to fulfill the public expectation of learning after error. Also, training has the potential to teach healthcare professionals how to better handle the conflicting demands that make medicine administration error-prone, potentially leading to fewer errors and relieving the pressure of error-prone care.

Article C, *The effectiveness of improving healthcare personnel's human factor skills using simulation-based training: a systematic review,* investigates the available scientific evidence for using simulation training for strengthening human factor skills. The review

genre is considered at the top of the evidence pyramid in health science, although some medical scholars suggest that the literature review is more of "a lens through which evidence is viewed" and a "tool (…) to consume and apply the evidence by stakeholders" (Murad, Asi, Alsawas, & Alahdab, 2016, 126-27). The point is true in the case of this thesis, where the review is precisely a tool for leveraging simulation-based team training to reduce adverse events and lessen the pressures on the hospital organization. The review is useful for hospitals and medical researchers when trying to come up with ways of improving human factors and reducing medical errors. Overall, the review finds that "SBT (simulation-based training) is an effective learning tool to improve HFS (Human Factors skills) in hospital healthcare settings" (Article C). It concludes that "a change of focus is recommended for healthcare providers not only to train emergencies or rare situations but also everyday non-emergency situations" such as mundane medicine administration. The article thus confirms the project hypothesis that simulation-based training can be a way of addressing human factors in healthcare that contribute to many adverse events.

Lastly, the thesis closes with Article D, *Beyond* No Interruption Zones *in the medicine room: patient safety through human factors training*. The article builds on the previous three articles: the knowledge of a common-sensical understanding of medical error is used to criticize the implementation of *No Interruption Zones* in hospital medicine rooms, as these zones are based on a cultural understanding of errors as individual acts. The impositions of No Interruption Zones can impede safe collaboration and a culture of speaking up among nurses. The article builds on the insight that hospitals must focus on learning in order to remain trustworthy in the public eye. It describes the building and testing of an in situ simulation-based training course for nurses focused on handling interruptions in the medicine room. It draws on the finding that nurses must balance the risk between interrupting colleagues and relying on them for collaboration. It is based on a simulation scenario that trains safe medicine administration under the stress of interruptions. The article demonstrates that simulation-based training is a way forward to reduce medication errors by training human factor skills. Through analysis of video ethnographic data, administration before training is compared with administration during training. It is concluded that medication administration is characterized by a leader-follower dynamic where more experienced nurses protect less experienced healthcare professionals from

interruptions by helping and shielding them. Simulation-based training strengthens the nurses' capabilities for handling interruptions by making them aware of interruptions and by making them aware of how to protect themselves and each other against them through role-taking.

The overall pattern that emerges from the four articles is that healthcare professionals operate in a medication ecosystem that puts pressure on the organization from both macro phenomena (i.e., societal myths about medical errors) and micro phenomena (i.e., medicine administration prone to error due to human factors and organizational constraints). The case hospitals of this investigation currently employ limited solutions not backed by solid evidence such as *No Interruption Zones* in medicine rooms. Such solutions come with their own problems of possibly impeding critical information sharing for patient safety. The thesis finds that there is significant scientific evidence for using simulation-based training for improving the human factors skills of healthcare professionals. It also finds that simulation training in the medicine room can improve the healthcare professionals' awareness of interruptions to medicine administration and reinforce a departmental safety culture, where professionals help each other balance organizational constraints by taking leader and follower roles in the medicine room. In the larger organizational ecology, simulation-based team training can serve to reduce the pressures put on the hospital organization by (i) signaling improvements and learning after error and (ii) reducing medication adverse through improved human factor skills among healthcare professionals in hospitals.

4.2 Conclusions

Based on the results summarized in the previous section, I answer the two research questions of the thesis here. The first research question is:

1. How can an empirically validated approach to the study of organizational ecology be developed by integrating cognitive, phenomenological, and organizational perspectives?

The thesis takes the novel approach of integrating the philosophy of phenomenological hermeneutics with the theory of distributed cognition. The integration leads to a combination of methods, specifically cognitive ethnography, Cognitive Event Analysis, phenomenological interviews, and hermeneutic interpretations. The integration allows the thesis to investigate organizational practices through the experiences of individual organization members and through descriptions of how people, artifacts, technologies, and cultures co-produce results. The integration is empirically validated through application in action research and a simulation-based training intervention at two hospitals in the Region of Southern Denmark. The integration allow the thesis to cover three gaps in healthcare safety found by safety researchers (Hollnagel, 2014; Leveson, 2020): (i) the gap of explaining how some happenings come to be experienced as medication errors while some do not, (ii) the gap of taking into account the entire system of medication safety so that safety does not become a local, limited achievement, and (iii) the gap of supporting healthcare professionals in conducting safe medicine administration while medication errors still emerge from a wider hospital ecosystem. By thinking healthcare safety from a humanities perspective it becomes possible to address and create knowledge that fills in all three gaps. Through phenomenological hermeneutics, the emergence of medication error as conscious experience can be studied. Through distributed cognition, the cognitive ecosystems of medication error can be explained. And finally, through action research, the combination of hermeneutics and distributed cognition can be developed with healthcare professionals, thus developing knowledge on how to support themselves.

The second research question is:

2. From the perspective of 'organizational ecology', how can qualitative knowledge on the paths towards reduction of medicine administration errors be developed through the organization of a non-technical skills training course for healthcare professionals?

The second question involves two elements. The first element is applying the integration of phenomenological hermeneutics and distributed cognition in an investigation of medication errors in order to reveal the complexities of error reduction. The second element is taking the results of such an investigation and applying them in the design of a

simulation-based training course that takes into account the phenomenology and distributed cognition of healthcare professionals.

In an answer to the first element, it is found that medication errors are hard to reduce because they stem from human factors. The thesis points to two of such factors as highly important, namely cultural and cognitive pressures on the hospital organization. On the cultural macro-scale, there is a shared myth that healthcare errors are meaningful events that allow healthcare professionals to learn and improve. The common sense is that errors decrease over time, although this is an unrealistic idea of healthcare adverse events, such as medication errors. This is because errors mainly stem from general human and organizational factors, not factors related to the responsibility and personality of individual healthcare professionals. The unrealistic image of medication error can lead to a decrease in public trust in healthcare professionals because hospitals cannot live up to cultural expectations. On the cognitive micro-scale inside two case hospitals, it is found that even safe medicine administration involves an increase of risks in other parts of the work because of the conflicting demands put on nurses administering medicine, such as both collaborating intensely and not interrupting each other in the medicine room. This dynamic makes medicine administration prone to error over time.

Answering the second element, the thesis finds that in situ simulation-based team training, in general, is an effective way of improving human factor skills of healthcare professionals. Further, it is found that training how to handle interruptions of medicine administration through in situ simulation training improves the awareness of interruptions among participating professionals and improves healthcare professionals' ability to deal effectively with the conflicting demands that are the source of many medication errors.

Overall, it is found that in situ simulation team training is an effective way of addressing the cultural and cognitive pressures of medication errors for the hospital organization. Preparing and reflecting on their clinical practice is fruitful for healthcare professionals. Without careful preparation of and reflection on medicine administration practices, the built-in risks of normal, safe medication administration go unnoticed and can incubate future error. It is important that healthcare professionals become aware of built-in risks, so that near misses are not merely interpreted as signs that the hospital system is working. Near misses should be thought of as signs that the hospital safeguards are

vulnerable. As Weick and Sutcliffe (2015, 61) argue, "Err on the side of danger. Interpret a near miss as danger in the guise of safety rather than safety in the guise of danger." Risks are not obvious but appear to us in certain ways. Risks come in disguise, sometimes even in the guise of safety and 'that is how we do things here'. Medication errors must be approached through methods that take into account how errors are interpreted by healthcare professionals so that incubating errors does not continue to be disguised as the safe, normal way of administering medicine. At the same time, medication errors require an ecosystemic conceptualization and analysis, because conflicting demands on staff stem from a wider organizational ecology extending all the way out to societal myths and expectations to healthcare organizations. Only by adopting an approach that can incorporate both the experiences of medication errors and the wider cognitive ecosystem in which medication errors emerge it can become possible to construct solutions that can lead to sustained reductions.

4.3 Discussion of results

In this section, I relate the thesis conclusions to the debate in safety research over what paradigm is more suitable for improvements to healthcare (cf., section 1.2).

In his description of a move from a Safety-I paradigm to a Safety-II paradigm in hospitals, Hollnagel (2014) argues that it is more suitable to study *work-as-done* rather than *work-as-imagined*. This means looking at the results and processes that healthcare professionals actually enact instead of using ideals and guidelines as a measuring stick. On the other hand, Leveson (2020) argues that focusing primarily on local *work-as-done* ignores the wider ecosystem that impacts work in the moment. She holds that we should think of safety as a system, rather than as a question of human behavior only, and that systems thinking has brought safety to many other crucial institutions than healthcare, for instance aviation. The ideas of how complexity arises in systems are thus very different between the two scholars. While Leveson's discourse points to an idea of errors stemming from dynamic complexity, where the causes and the errors are distant in time (and can thus be designed for to some degree), Hollnagel imagines the complexity of hospitals as social and emergent, where the different views and interests of actors cause disruptive

unpredictability. In Hollnagel's view, the more complexity a system contains, the less humans will become in control of its functioning. The more a system is *engineered*, the more unknowns are introduced when humans interact within it. The unknowns create new potentials for failure that the original designer of the system could not or did not consider. Safety-II is Hollnagel's proposal for bringing safety back in the hands of humans, by focusing on their capabilities within a system. What Hollnagel proposes is a psychological shift in the way we think about safety, from an idealized practice that must not go wrong to an empowerment of human actors who are provided with the tools and support they need for successful performance. First, I will address what the thesis results have to say about these arguments from Hollnagel, before addressing the arguments of Leveson.

I have adopted Hollnagel's proposal of focusing on how errors and safety are perceived in and around healthcare. Still, the thesis conclusions have put the finger on at least two issues with Hollnagel's argument. The first issue is the practical problems of switching to a new way of thinking about safety for healthcare professionals and management. Shifting an organizational culture is not easy, and we should remember that organizational cultures play essential roles in guiding and controlling action. As Hutchins (2014, 38, 48) explain, "cultural practices tend to reduce entropy (increase predictability) at all scales in a cultural cognitive ecosystem" and cultural practices also "increase the predictability of experience". When suggesting that hospitals should adopt a new safety mindset, what Hollnagel is really asking is therefore to give up predictability and control. I am not saying that a Safety-II paradigm could not benefit healthcare, but I am pointing out that the current predominant paradigm exists for other reasons than safety. It also serves a role of predicting and signaling. Concretely, I have found that two pressures exist on the hospital organization (see Figure 7), that is the external pressure of public perception and the internal pressure of error-prone care. The problem is that a Safety-II paradigm of focusing on successful, everyday performance does not alleviate either of these pressures. While it might reduce medication errors to some degree, it does not satisfy the public expectations of a learning hospital. What about the medication errors that will still exist under a Safety-II paradigm, due to the error-prone nature of medicine administration? The relevant question becomes if we should then *accept* these errors? I suspect that this is an unthinkable stance for hospital management that is beholden to a public and to the media. Realistically,

the official line for hospitals must be that *all* errors should be prevented. In democratic countries hospitals are public institutions, where elected politicians are perceived as ultimately accountable. Because medication administration is error-prone over time, even within a Safety-II paradigm, the public and politicians will demand increased accountability. A Safety-I logic of reactive accountability thus creep back in. While this thesis has adopted the proposals of Hollnagel, its results have shown that there are problems with a Safety-II paradigm from the angle of cultural perceptions of error and from the angle of actual cognitive problem-solving in hospitals. When you consider the public understanding of error and the error-proneness of medicine administration, Safety-II looks like a *limited* and *idealized* version of healthcare safety more than an actual solution, which is ironically what Safety-I is criticized for from the perspective of Safety-II.

With the problems of Safety-II in mind, the question then becomes if Leveson's (2020) concept of Safety-III provide a convincing correction to Safety-II in the light of the thesis's results. Leveson (2020, 105-6) argues that healthcare requires "designing (engineering) the entire system for safety" and using "top-down, holistic approaches that allow us to handle the complexity of today's high-tech, complex systems." She relays how such an approach has made aviation and other industries much safer. While, I agree with this assessment, I also conclude that systems thinking and cognitive engineering will not eradicate medication errors either. The reason is that designing healthcare is different from designing a safe airplane. In the latter case, the designer will only have to engineer the airplane once and then copy the design to all other airplanes of that type. Healthcare is vastly more complex when it comes to the amount of social and cross-institutional interactions, technological innovations, and changes in work procedures. While some weather conditions will keep airplanes on the ground, healthcare will have to keep operating under the worst possible conditions. While a plane will not fly without a pilot, hospitals must operate even when the doctor does not show up. Some things will go wrong in hospitals due to the collaborative, evolving nature of the work, and things that go wrong will impact the things that go right. So cognitive engineering for a safe hospital is more of an endless task because tasks and methods keep changing. Nevertheless, it should be tried, but we should not expect total patient medicine safety from Safety-III either, due to the cultural-cognitive complexity of medication practices revealed in this thesis.

In the next section, I describe a potential way forward in the light of the described shortcomings of Safety-II and Safety-III.

4.4 Future implications

In this final section, I present some future perspectives for humanities-based hospital safety research based on the approach and results of this thesis.

How do we go beyond the paradigmatic numerals of Safety-I, II and III and towards an approach to medication safety that will actually ensure reductions of error? This thesis points toward an integration of Leveson's (2020) proposed systems thinking and Hollnagel's (2018) proposed psychological shift. I have shown that there is no contradiction in *both* focusing on the empowerment of nurses and doctors *and* on ecosystemic risk factors. Concretely, I have designed a simulation course in collaboration with healthcare professionals that focus on the interruptions that are constantly produced in the interactions of the hospital ecosystem, while also providing the individual healthcare professionals with tools for dealing productively with these. In line with the findings of Lavelle et al. (2020), simulation training is shown to be a viable method for intervening in healthcare practice and to produce knowledge on these practices at the same time. Training and reflecting while video recording allow researchers and healthcare professionals to develop safer practices together. Training allows for both *practicing* and *talking* about practicing – that is, talking about if and how professionals want to develop their practices.

Simulation-based team training is only one example of possible ways of intervening between the individual professional and their organizational ecosystem. Other methods that allow for opening a possibility space between *doing* and *developing* are feedback sessions and workshops after specific procedures in healthcare. The basic framework is to not go over the heads of healthcare professionals, telling them to adopt Safety-II, Safety-III, or some other safety paradigm, but instead letting professionals be a part of how safety appears and how errors appear. I have found that nurses and doctors are highly aware and motivated to comply with healthcare guidelines, as long as they think it helps the patient. In many situations, healthcare professionals have to make quick decisions in which they weigh safety against efficiency and other organizational demands. The problem is that

most of such situations slip through the hands. Most situations are never reflected upon and learned from. This thesis has presented one way of learning from error, by adopting an ecosystemic analysis of interruptions and translate it into a simulation course curriculum (cf., section 3.2). It is based on the idea that healthcare practitioners gain from simulation of even normal, mundane situations, for instance those situations that constitute most of the functioning medication ecosystem: medicine rounds, receiving patients, and giving information to next of kin. All these situations are normal, everyday situations where error can become incubated as trivialized risk. Such everyday situations must be analyzed and trained to produce increased awareness of incubating errors, and such a way of training and reflecting is currently not the norm in hospitals.

Combining a focus on the cultural perceptions, the distributed cognitive system, and the actual experiences of medicine administration at the ward is a novel approach that go beyond the numerals of Safety I, II and III in healthcare. Studying medication safety from a humanities perspective has allowed this thesis to combine cultural and experiential aspects of care with cognitive descriptions of how errors emerge. Although we now know that patient safety is determined by both human and systemic factors, current safety research in healthcare lacks the integration of the two aspects. This thesis presents the argument that we must walk in this direction. However, only future research can determine if the combination of phenomenological hermeneutics and distributed cognitive science can lead to actual reductions in healthcare medication errors.

Afterword

One day during our ethnography, I asked an experienced nurse when she last had trained medicine rounds. She looked at me, puzzled. She had not trained medicine rounds since training to become a nurse, many years ago. “Well, doing is also kind of training, right? And I do it all the time,” she said. The nurse was right, she had become skilled in medicine administration through repetitions every day. But she had not been given the opportunity to simulate her performance of everyday medicine rounds, in the way that I explain in Article D of this thesis. For this nurse, medicine administration had become something you do, not something you reflect upon. And what simulation training does is exactly opening a space to reflect and weigh if one should course-correct.

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PART II

Article A**:** The social contract of medical error: understanding adverse events in medical television dramas

(Submitted version)

The social contract of medical error: understanding adverse events in medical television dramas

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Abstract

Background: Today's popular medical television dramas tell stories of fallible physicians and have medical researchers concerned about the cultivation of unrealistic care expectations. However, medical studies have only narrowly assessed the realism of error in medical television dramas and not the narratives or messages communicated to the public about healthcare adverse events on television.

Methods: To understand cultural perceptions of medical error, three error-themed episodes of medical television dramas *Grey's Anatomy*, *Scrubs* and *House* are interpreted qualitatively through a philosophical hermeneutic framework.

Results: It is found that healthcare adverse events are presented as common and unavoidable due to human fallibility in medical television dramas. However, errors are also presented as meaningful events that are ultimately redeemed in the television narrative as learning opportunities for physicians and nurses.

Conclusions: Messages in medical television dramas about adverse events does not provide a realistic portrayal of healthcare failures. Instead, the message of errors as meaningful events, filled with potential for clinicians to learn and get better, reflect a public

perception, also known as a *social contract*, that errors are tolerable if hospital staff is perceived as continuously learning from them.

1 Introduction

> The function of film is to train human beings in the apperception and reactions needed to deal with a vast apparatus whose role in their lives is expanding almost daily. (Benjamin, 1936, 107)

The above epigraph might as well have been written about television, but Walter Benjamin did not live long enough to witness the expansion of film into household television, nor the ensuing flood of medical television dramas (MTDs). Like film, the popular MTDs can precisely be a way for people to make sense of the complex apparatus of healthcare (Tian & Yoo, 2020), and scholars have highlighted the role of mass media in shaping public perceptions of institutional failures (Tulloch & Zinn, 2011; Zinn, 2008). In this light, it is telling that the narratives of MTDs have undergone a significant change since their beginnings in the 1950s: where twentieth-century MTDs would generally portray healthcare professionals, especially doctors, as infallible heroes, twenty-first-century dramas feature a younger, more attractive set of characters that make mistakes (Foss, 2011; Jacobs, 2003; Strauman & Goodier, 2008; Turow, 1996) suggesting a need for the public to comprehend and manage anxieties of medical error. Medical researchers have noticed the trend of depicting error in popular MTDs too, but they are more concerned. For example, Serrone et al. (2018, 1) find that the messages of healthcare in MTDs "cultivate false expectations among patients and their families". So, does the depiction of error on television help the public to make sense of widespread medical errors or are MTDs spreading misinformation? This article aims at understanding what messages about medical error are consumed by audiences of MTDs and why error narratives have such a rich cultural resonance.

This article starts by discussing the context of concerns with MTDs voiced in medical journals. Then, the article presents the methodology of philosophical hermeneutics and applies this framework to three MTD episodes that tell stories of medical error. In the last

part of the article, it is discussed what messages are cultivated about medical error and if the portrayals of errors in television fiction are realistic.

2 Background

Several medical researchers have studied MTDs with two distinct branches of research. One branch has studied MTDs as an educational tool on health students. Here, the consensus is that MTDs can indeed be used to educate medical and nursing students on ethics and professional behaviour (Czarny, Faden, Nolan, Bodensiek, & Sugarman, 2008; Foster & Roberts, 2016; van Ommen, Daalmans, & Weijers, 2014; Weaver, Wilson, & Langendyk, 2014; Wicclair, 2008) and also on diseases and medicine to some extend (Baños, Lucena, & Farré, 2019; Jerrentrup et al., 2018). These studies rely on the hypothesisw that medical students are more informed and critical than the general public: "students begin their studies from a more critical perspective about the realism of medical television programs" (Weaver et al., 2014, 4). The show *House* is considered particularly useful for teaching even though the protagonist Dr House behaves unethically, because students "are critical enough not to see Dr House as a role model for their own personality" (Jerrentrup et al., 2018, 1). Wicclair (2008, 17) hypothesises that "insofar as medical students are able to distinguish between the fictional/fantasy world of *House* and actual medical practice, there may be no need for concern about the show's negative influence on them". Similarly, Baños (2019, 302) writes that "the situation depicted in the series is so exaggerated that it is difficult to believe that students would consider this way of behaving acceptable under any circumstances. In fact, *House, M.D.* can be used to highlight important ethical issues, as it portrays the way a physician never should behave."

While students are hypothesised as being critical enough to see through unrealistic and unethical depictions of medical practice, researchers do not consider the same true with the general public. A common argument among clinical researchers is that dramas depict "unprofessional behavior (…) which could distort public perceptions" (McFadden et al., 2020, 1034), leading to "the need to counter misinformation" (Bitter, Patel, & Hinyard, 2021, 1). Several articles study the portrayal of cardiopulmonary resuscitation (CPR) and seizure aid in MTDs, with Moeller and colleagues (2011, 723) showing that

MTDs tend to depict first aid that does not comply with proper guidelines and "may contribute to misinformation of the general public". Van Den Bulck (2002, 328) found a relationship "between the consumption of MTD and higher estimates of cardiopulmonary resuscitation survival" and argues that overemphasising successful CPR can have psychological consequences if audiences find themselves in a situation where CPR fails after watching MTDs. He imagines a situation where "the physician will have to tell individuals their family member did not survive the procedure that they believe has a high rate of success" and "it may lead them to believe that unsuccessful CPR is a result of malpractice". Bitter and colleagues (2021) finds that "MTDs continue to (…) portray favorable outcomes more frequently than should be expected. Patients who believe the overly optimistic prognoses portrayed on television may be more likely to desire aggressive medical care in the face of serious illness" and warns that "healthcare workers should anticipate the need to counter misinformation". Lapostolle et al. (2013) find that the examination strategies in *House* are unrealistic, and "because of this distortion, patients may not understand, nor accept the delay, the investigation choices, the intervention costs, risks, nor failures of a daily medical practice." It is evident that the depiction of uncompliant medical procedures and overly successful outcomes has researchers worried. Throughout the above studies, MTDs are compared with real-life medical procedure guidelines. This framing, however, tells us little about what messages on medical error is carried to audiences, only what medical researchers consider erroneous from a clinical perspective (i.e. actively looking for non-compliance with medical guidelines although lay viewers may not notice non-compliance). To understand how viewers actually do perceive medical errors on MTDs, instead of what trained medical researchers consider medically erroneous, I now move to an interpretive analysis of error in three MTDs.

3 Methods

Below, three episodes of three popular MTDs, *Grey's Anatomy*, *Scrubs* and *House*, are analysed using the philosophical hermeneutics from Gadamer (1960) and organic hermeneutics of Bortoft (2012). As shown above, medical errors in dramas have not been analysed with an interpretive framework, as an artwork on its own terms. This means that

studies have ignored the messages that MTDs relay to the public about medical errors, instead focusing on guideline compliance that make little sense to a lay public. Philosophical hermeneutics is chosen as a methodology because it is a theory of interpretation. A key point of Gadamer is that scientific investigations claiming objective truth rarely realise their hidden assumptions and prejudices about the subject matter, just like the above-mentioned medical studies assume a non-compliance model of error (i.e., study if characters follow medical guidelines) and claim that only depictions of compliance with guidelines are realistic. Building on Husserl's phenomenology, Gadamer explains that "the constitution of the scientific world presents a special task, namely of clarifying the idealisation" (Gadamer, 1960, 249). That is, objective criteria should be thought of as idealising some narrow part of reality. To Gadamer (1960, 249), "science is anything but a fact from which to start" and "not the most fundamental task". The previous medical studies of MTDs assesses MTDs through objective criteria of compliance or noncompliance, and to Gadamer, this is problematic because it is only an instance of the television drama. In other words, a 'special case' is picked out by researchers without understanding if this case is important to how the drama is experienced by other viewers. For example, several researchers count instances of deaths after CPR in different MTDs and compare with statistics of deaths after CPR in real life and conclude that representation of CPR is unrealistic (Diem, Lantos, & Tulsky, 1996; Portanova, Irvine, Yi, & Enguidanos, 2015). These studies illustrate the selectivity of a scientific paradigm that ignores the lived life of actual viewers that does not watch many different MTDs at once and count the deaths. Perhaps a few viewers do watch television like that, but chances are that they are either a medical researcher or, as argued by Gadamer, only a 'special case'.

Although hermeneutics was developed with a focus on written texts and not television, Gadamer was clear that the object of philosophical hermeneutics is not limited to text but must "embrace the whole sphere of art and its complex of questions. Every work of art, not only literature, must be understood like any other text that requires understanding" (Gadamer, 1960, 157). He argued that the *truth* of a work of art, even the truth about medical error in MTDs, is not found in universal natural laws or through mechanical procedures such as counting instances of inadequate CPR. A work of art is experienced by an audience, so the experiencing must be included in the analysis. Truth, when it comes to

art, is found "in-between" people, artefacts and traditions (Gadamer, 1960, 295). This does not mean that works of art are pure social constructions or contain no truths, only that the truth is intermediate as meaning, or what hermeneutic thinker Bortoft (2012) calls a *self-differencing* ingrained in all cultural texts such as television. As he writes, "the meaning of a text is akin to a form of life in that it is not 'finished work' but always becoming" (Bortoft, 2012, 118). A text always contains the possibility of many meanings, a multitude of self-differences, and that "these self-differences constitute the dynamic unity of the work itself and not the disintegration of the work into many different meanings" (Bortoft, 2012, 118-19). This is the understanding of MTDs employed in this article, namely that MTDs contain truth that can be analysed as dynamic and unfolding.

In this article, the concrete steps used to uncover the dynamic meaning of medical errors in MTDs follow Gadamer's and Bortoft's principles of hermeneutics. Two important principles applied in the analysis below is the writing forth of the author's preconceptions and understandings of MTDs, because new interpretations arise based on prejudices (Gadamer, 1960, 271). Another principle applied in the analysis is to let any interpretation of the dramatic elements illuminate the whole of the drama episode and vice versa, as meaning is thought of as a movement between text and context, between the part and the whole (Bortoft, 2012, 13). So, while specific elements of the MTDs will be pointed out below, these will also be compared with the entire MTD episode and pilot season. However, it may not be productive to describe more precisely the methodological steps, because, as Gadamer explains, "there is no hermeneutic method. (…) Hermeneutics means not so much a procedure as the attitude of a person who wants to understand someone else" (Gadamer, 1997, 168). The below analysis is thus best understood as an attempt to write forth the experience of watching a MTD to understand what it wants to tell audiences about medical adverse events.

The selection criteria for these specific MTDs are first and foremost that they are included in many of the above-mentioned scientific studies. Each of the three television dramas also represents a different genre-take on the MTD and thus on medical error, making it possible to compare across genres. Broadly, *Scrubs* is comedy, *Grey's Anatomy* is romance and *House* is mystery. In contrast with previous studies described above, the focus of this article is mainly the first season of these three dramas, based on the hypothesis

that the first season establishes core ideas and narrative tropes of the television series. In other words, the pilot season should set up a thesis on medical error. To keep the analysis concise, one episode from each MTD is selected for in-depth analysis based on what episode features medical errors as a major theme. References to episodes are written as (Scrubs 1-23) which means *Scrubs* season 1, episode 23.

4 Results

4.1 Adverse Events on Scrubs

> (Maybe) you aren't as good as you thought you were. (…) When you hit that low point, you have a choice. You can either wallow in self-pity, or you can suck it up. It's your call. (Scrubs, 1-23)

Scrubs is a comedy series that ran from 2001-2009. The series follows medical intern Dr Dorian and his colleagues, working to become resident doctors. Season 1 takes a light tone on medical work, but as the prospects of residency approach for the interns, the last four episodes of season 1, episode 21-24, are darker and deals with the issue of error and hardships of doctoring. Especially episode 21, *My Sacrificial Clam*, revolves around an adverse event happening at the beginning of the episode. Nurse Roberts is testing a patient for hepatitis by taking a blood sample while Dr Dorian observes from the other side of the bed. While holding up the blood-filled syringe to squeeze out excess air, a second nurse walks into Roberts's back and the hepatitis-test syringe flies in an arch over the bed and lands in Dr Dorian's arm. The situation is presented as a complete accident caused by all the healthcare staff being too busy and inattentive: nurse Roberts says that she has tickets to a show and wants to get the procedure over with quickly. Dr Dorian taps his fingers impatiently on the patient bed table as if he has other things to do. A second nurse arrives, too busy to consider his surroundings, and bumps into Roberts's back.

While the 'flying syringe' adverse event occupies only one scene of the episode, a majority of episode runtime is given to the chain reaction triggered by the event as it sets different plotlines in motion. The head of medicine, Dr Kelso thinks that the adverse event

is Dr Dorian's own fault and makes Dorian sign a form that relieves the hospital of liability. Other colleagues frame the event as an unavoidable accident – "everybody eventually gets stung" says nurse Espinosa to Dorian. Dorian himself becomes scared of his patients after the mistake. "I'm a doctor who's afraid of sick people!" he exclaims later, even though it was not the patient, but staff inattentiveness that caused the incident. His mentor, Doctor Cox, tells him: "You're a doctor. You might get sick. Get over it!", framing mistakes as an unavoidable hospital event. The episode concludes with Dr Dorian accepting this framing of error as inevitable and instead beginning to see it as an opportunity to grow personally by taking responsibility: "When you start med school they warn you that you are gonna have to make sacrifices. (…) At some point, you might even have to give up your own sense of safety and well-being, but after a while, it doesn't feel like you're giving up anything at all". In contrast with Dorian's manager Dr Kelso, who is quick to dismiss his own liability, Dorian takes responsibility and gains courage from the event.

The episode of *Scrubs* does not seem interested in what caused the medical error. While the show explains the spectacle of a flying syringe with everyday busyness among healthcare staff, the flying syringe is depicted as a complete accident. No staff member is curious about how the adverse event could happen, and the camera only traces how the characters handle their emotions and reactions to the flying syringe. This can stem from the overall narrative of unskilled interns becoming skilled resident physicians. In this light, the meaning of the flying syringe is tied to how it reveals courage in characters that step up and take responsibility for their own fallibility. Medical mistakes, like the flying syringe, play a crucial role in this developmental arch as the final obstacle of season 1 in *Scrubs*, as something that must be overcome to become a resident. It is interesting how *Scrubs* find a narrow path between its thesis that all doctors make mistakes and still retaining that the viewer should be sympathetic towards the flawed characters. *Scrubs* put forward the idea that no doctor is perfect and instead striving is considered a heroic act. As Dorian puts it: "(This was) the day I realised that admitting we're not heroic, is when we are the most heroic of all" (Scrubs, 1-23). The show frames mistakes as events that reveal if people are willing to admit their weaknesses and learn from them. This might sound like a reversal of the idea of classic hero narratives because *Scrubs'* narrative emphasises striving rather than heroic acts. However, the trope of heroic striving is as old as

modern hero fiction itself. E.g., *Doc Savage* from 1930, one of the earliest cartoon superheroes and considered the forerunner of modern superhero fiction, was a doctor and always repeated an oath that was similar to Dorians: "Let me strive every moment of my life to make myself better and better." The resemblance with classic superhero-fiction emphasises that *Scrubs* considers its characters true heroes precisely because of their mistakes and ability to face and learn from them.

The point of revealing heroism through failures is also emphasised when Dorian courageously steps up to tell a cancer patient that he will die in episode 23. Behind Dorian, a cappella group sings the theme "Underdog" from the 1960s cartoon by the same name, but they transform dog to doc: "Now unleash the Doc of wonder! Tearing evils bonds asunder! Under-Doc!" In the original cartoon, a superhero dog would always cause catastrophic collateral damage while trying to stop criminals. Whenever someone complained about the damage, Underdog would answer: "I am a hero who never fails (because) I cannot be bothered with such details". The song thus describes the dilemma of the doctor trying to do good deeds, but inevitably causing mistakes and reinforcing the trope that taking responsibility for the inevitable collateral is the real heroic act. So, while medical mistakes rarely concern patients on *Scrubs*, they do provide the audience with information about the characters of the show: Dr Dorian is good because he takes responsibility and learns. Dr Kelso is bad because he is arrogant and does not want to take responsibility as a manager. In other words, medical adverse events play a revelatory role in *Scrubs* – they reveal character traits and who the real heroes are and who the audience should feel sympathy for: usually the protagonist physicians and nurses and seldom the patients in the background.

4.2 Adverse Events on Grey's Anatomy

> We have to make our own mistakes. We have to learn our own lessons. Even the worst, most intractable mistake beats the hell out of never trying. (Grey's Anatomy, 1-6)

Grey's Anatomy is a MTD running from 2005 till now. Like *Scrubs*, *Grey's Anatomy* follows a group of interns on their way to becoming surgical residents, but the show features a romantic tone and a focus on feelings and relationships between the surgeons. In

season 1, episode 5, *Shake Your Groove Thing*, is centred on the theme of adverse events. The episode starts with Dr Burke performing cardiac surgery on a patient while the main protagonist, Dr Meredith Grey, is tasked with holding the patient's heart in her hands. She is visibly tired from a family conflict and nods off shortly, making her lose the grip of the heart shortly and fracturing both her glove and the heart with her fingernail when she grasps the heart. Meanwhile, another patient is in surgery for lung pains and a surgeon finds a towel inside the patient that was forgotten during surgery at the same hospital five years ago. In the paperwork, it is discovered that it was Dr Burke that had left the towel five years earlier.

Like in *Scrubs*, the mistakes on *Grey's Anatomy* are experienced as a matter of personal responsibility, arguably due to the same theme of young interns learning to become doctors. Like the flying syringe in *Scrubs*, the specific representations of mistakes in *Grey's Anatomy* are equally dramatic: camera close-ups of a bloody towel inside the bowel and a bloody, fractured glove. Further, the show is also not concerned with investigating contributing factors to the adverse event, such as a faulty glove, other than Dr Grey's own experience of the event and the bad conscience she now faces. As Dr Grey says after her mistake, "the scariest part about responsibilities - when you screw up", thus taking all the responsibility of the adverse event on herself. Eventually, both Dr Grey and Dr Burke take responsibility for their mistakes and Dr Burke explains: "Even great doctors make mistakes!". After his admission, Dr Burke apologises to the harmed patient and both he and Dr Grey are rewarded for their honesty with respect and compassion from their colleagues. In this way, the show focuses mainly on concrete missteps of doctors as well as their emotions and heartaches afterwards. The error itself is experienced as less important than the reaction of the characters to this obstacle. Medical errors in *Grey's Anatomy* are meaningful events that work as metaphors for the flawed personalities and developmental arches of its doctor characters. Medical errors are in many instances what sets the plot in motion, like Dr Grey's "mistake" in episode 1 when she sleeps with the, unbeknownst to her, head of her new ward. In this way, mistakes are what brings the characters into emotional contact with each other as they expose their weaknesses. Dr Grey's mistake of nicking the heart in front of Dr Burke is countered with Dr Burkes own mistake of forgetting a towel five years prior. The moral is clear: human error is inevitable, and good

doctors take personal responsibility for their mistakes. As Dr Grey explains in a later season:

> Patients see us as gods, or they see us as monsters. But the fact is, we're just people. We screw up, we lose our way. (...) So, we force ourselves to keep trying, to keep learning. In the hope that maybe someday we'll come just a little bit closer to the gods our patients need us to be. (Grey's Anatomy, 5-16)

All characters of *Grey's Anatomy* are flawed individuals that produce mistakes when they interact with their surroundings. However, all main characters try to be good people, and errors are what reveal their virtues: The characters are morally stressed over doing good deeds as doctors while being mere humans with feelings. Errors are therefore not accidental or systemic on *Grey's Anatomy*, rather they are tied to deeply personal and existential conflicts and reveal the growth of characters who strive to do good. The show addresses a younger audience who, in their teens or twenties, may identify with the crisis of identity and skill. Dr Grey often addresses a young audience directly: "Remember when you were a kid and your biggest worry was, like, if you got a bike for your birthday or if you get to eat cookies for breakfast. Being an adult - totally overrated. (…) Adulthood is responsibility" (Grey's Anatomy, 1-5). The characters of *Grey's anatomy* are caught between adolescence and adulthood, at least in the first seasons, and medical errors are spawned from this existential crisis. As such, medical adverse events are not experienced as relating to the healthcare system but only to the growth of Dr Grey and other doctors. Taking responsibility for error is the rite of passage to adulthood for Dr Grey. The basic thesis on medical errors on the show is that "even the worst, most intractable mistake beats the hell out of never trying" (Grey's Anatomy, 1-6). This line clearly communicates that errors relate to physician striving and learning.

4.3 Adverse Events on House

> We all make mistakes. And we all pay a price. (House, 1-8)

House, in most studies called *House M.D.*, is a television drama running from 2004-2012 following Dr Gregory House in his work as an expert "diagnostician", a role that

supposedly does not exist in real hospitals. The show is different from *Scrubs* and *Grey's Anatomy* from the start, mainly because *House* is already the foremost expert diagnostician in the hospital when the viewer meets him in season 1. Instead of focusing on character growth, the show is concerned with solving mysterious cases of disease with the help of a team of younger doctors. The different angles and genres also make the shows take on adverse events differently from *Scrubs* and *Grey's Anatomy*.

How are mistakes portrayed in *House*? In season 1's episode 6, *Poison*, a teenager is admitted with symptoms of poisoning. Dr House first thinks the patient overdosed on drugs and puts him on an antidote for overdose. The patient then has a seizure that, according to Dr House, is not a symptom of drug use. Based on this new information, the team suspects the patient has been poisoned with pesticides and tests confirm an organophosphate in the patient's blood, so Dr House puts the teenager on a general Pralidoxime cure, but this causes him to have a cardiac arrest. From this, the team deduces that they need to target the specific type of pesticide, but they still do not know how the teenager was poisoned, so they start looking for environmental clues. Dr Cameron finds an empty can of disulfoton pesticide in the family shed and assumes that he used that, so the team wants to start targeting that pesticide, but the patients' mom insists her boy did not use pesticides in the garden. Dr House persuades the mom, but at that moment, another teenager is admitted to the hospital with the same symptoms, ruling out the fertiliser in the shed as the culprit. The team now starts searching for places where both teenagers could have been poisoned together. Dr Cameron discovers that the boys take the same school bus and that the county authorities were spraying ethyl-parathion pesticides near the bus route, but again the mom will not let them treat that pesticide, thinking that it is another misdiagnosis. Again, the team pressures her, and she accepts. However, the treatment for ethyl-parathion poisoning does not work either, and now both patients have seizures. Finally, the team discovers that both patients were wearing new unwashed jeans and they do find a pesticide on the jeans. Again, the mom does not want them to treat the son based on this discovery. She wants a second opinion, but Dr Chase cheats her into thinking that another doctor will not be available for months. So, the mom accepts the treatment and both teenagers recover.

During this episode, Dr House treats the first poisoned teenager with the wrong medicine three times, contributing to seizures twice and a cardiac arrest once. While it is hard to classify misdiagnosis as a medical error, since the differential diagnosis method used by doctors only provides the best guess based on symptoms and tests, the process of deduction by Dr House and his team is error-filled. Specifically, the team has a strong anchoring bias, which is a focal tendency on an initial piece of information available – a common error in diagnosing (Newman & Kohn, 2020, 310). For instance, Dr Cameron goes to the family home three times, each time discovering a novel clue that explains the symptoms and each time stopping her search after finding just a single clue. The bias is thinking that because a piece of information is newer in time, it carries more significance. The interesting part is that the show does not seem to consider this process an erroneous cognitive process; rather, the trial-and-error is a sign of Dr House's competency in diagnosing. The only person who realises that the team's method is flawed is the mother, and she is ridiculed and eventually cheated into submission. To the show, she is a layperson who cannot see through her emotions and comprehend the complex process of medical work in *House*.

House's framing of adverse events as the trial-and-error process of differential diagnosis can stem from the show's roots in the detective genre and especially the stories of Sherlock Holmes. It is not accidental that the surname of the leading character, Dr House, is a wordplay on Sherlock Holmes' surname (in English pronounced as "homes"). The show has many references to Sherlock Holmes such as Dr House's address that is 221b Baker Street. Sir Arthur Conan Doyle, the author of Sherlock Holmes, was himself a physician and the method of differential diagnosis did inspire him to let Sherlock Holmes be a master of the deductive method (Fitzgerald & Tierney, 1982; Miller, 1985). Medical differential diagnosis is a type of deductive method where a doctor will differentiate between diagnoses based on the symptoms, reactions to treatment, and other clues (Gill, Sabin, & Schmid, 2005; Newman & Kohn, 2020, 308). The goal is to exclude the possible diagnoses by observation and testing and hence narrow down a conclusion. Concerning medical mistakes, Dr House and his team make several medical errors in almost every episode, but these serve to advance their understanding of the patient's disease. With every error, House gets a clearer reading of the mysterious disease, because the error provides

information. Errors are thus part of House's praxis, and the only grave mistake that House could make would be not to experiment with patient treatments following Sherlock Holmes's creed from *A Scandal in Bohemia:* "It is a capital mistake to theorise before one has data" (Doyle, 1892). In other words, the biggest mistake Dr House could make would be not to do trial-and-error experiments on his patients, and medical mistakes are embedded in Dr House's radicalised version of the differential diagnosis method. Medical errors are the price of narrowing down treatment possibilities in the acute situations of *House*. Like *Scrubs* and *Grey's Anatomy*, mistakes are thus experienced as relating primarily to doctors, only in *House* they do not provide clues about character traits but about illnesses instead. The viewer is left with the understanding that the concerned mother in episode 5 should feel lucky that Dr House and his team experiment on her son, somehow ignoring that Dr House would probably have killed the patient several times over, were it not for the mother's objections.

5 Discussion

> The sleeping giant has awoken. (The public) are increasingly aware of the safety problems in medicine, and they are applying pressure. (Bates & Gawande, 2000)

As shown in the analysis above, medical errors play an important role in MTDs. They appear in the narrative as a promise of justice: something bad happens, but the error leads to some new development. A doctor will learn something or find a diagnostic clue due to the error. The message cultivated around medical errors is not the idea of error as incompliance with medical procedures as previous medical studies of MTDs assume. Often, correct procedures carry little significance and are not overly important to the narrative. Rather, stories in MTDs centre on medical errors as an unavoidable human factor of healthcare and fixate on how doctors experience and deal with their fallibility. Medical errors carry the significance that the doctors can find redemption by learning from failure – for instance by finding courage or the right diagnosis.

It is a realistic depiction of medical adverse events that they primarily relate to intersubjective and cultural factors and not inadequate technical competence (Kohn, Corrigan,

& Donaldson, 2000). However, the idea of justice and redemption after errors is not a realistic depiction of how medical adverse events unfold in medical practice. In actual healthcare, adverse events do not carry some essential meaning or clue that leads to redemption. Studies into the phenomenology of error find that physicians and nurses do not experience medical errors as possibilities for learning and redemption but as continuous experiences of sorrow (Paget, 1993, 2004) and immense suffering following second victimisation of healthcare professionals. Medical errors produce significant psychological traumas in healthcare professionals involved (Sirriyeh, Lawton, Gardner, & Armitage, 2010; Winning et al., 2018) which creates a spill-over effect where patients and colleagues are affected too (Seys et al., 2012). Hospitals, therefore, require extensive second victim support programmes (Baas et al., 2018; Chan, Khong, & Wang, 2017) which are not widely implemented (Ullström, Andreen Sachs, Hansson, Øvretveit, & Brommels, 2014). So, in our current reality, it seems that healthcare errors are not the meaning-filled drivers of growth potential for healthcare professionals presented in MTDs, but instead evidence of a healthcare institution in crisis and a workforce in distress.

If the depiction does not correspond with reality, why are medical error then continuously depicted as redemptive events? The epigraph by Walter Benjamin suggests that MTDs play a sense-making role for a public puzzled and worried about failing healthcare services. On that view, the analysis suggests that MTDs play an important societal role as drivers of trust in healthcare by propagating a narrative of redemptive justice. The phenomenon is well-known in studies of reactions to catastrophic events that threaten societal stability where researchers often find widespread 'just world' beliefs, that is, ideas of justice for mistakes that will eventually be handed out by some benevolent force (Wilson & Darke, 2012). The belief is often communicated in the media through purification rituals, for instance, public hearings and apologies after catastrophes such as oil spills. Wilson and Darke (2012) have shown that when people hold 'just world' beliefs, the face of threats paradoxically causes them to enhance trust in the failing organisation. This effect suggests that the presentation of many medical mistakes in television could enhance public trust in healthcare if MTDs push narratives of justice and redemption after error, which is what they do according to this analysis. The above analysis points to a variation of the myth of justice after errors in *Scrubs* and *Grey's Anatomy* where justice is served when doctors go

through the purification ritual of apologising, taking responsibility and 'learning their lesson'. In *House*, the purification ritual does not relate to personal growth, but rather the process of discovering the correct diagnosis - a take on the classic detective narrative of exposing evil by 'solving the case'. In other words, the reassuring message of redemptive justice has "therapeutic" effects on a public (Humphreys & Thompson, 2014).

A useful concept for understanding the public need to make sense of healthcare failures is Hobbes's enlightenment idea of a societal *Contract*, later developed by Rousseau as *social contract*. According to Rousseau, a social contract is a deal of mutual insurance: "Is it not nevertheless a gain to risk for the sake of what makes for our security just a portion of what we would have to risk for our own sakes as soon as we are deprived of it?" (Rousseau in Gourevitch, 1997, 63-64). In other words, although societal institutions are not perfect, they are better than providing for everything yourself. For patients, this means that even though medical error is a real possibility, the risk of harm is still worth taking because they would be worse off without medicine and healthcare. However, as with all risk systems, if the risks are perceived as too great, it can undermine trust, as have happened with the anti-vaccine movement (Korn, Böhm, Meier, & Betsch, 2020), and lead to public health catastrophes. The issue of retaining trust is, and always have been, therefore of utmost importance for both the public and hospitals. The original social contract of modern healthcare was expressed by Florence Nightingale in the first sentence of her first book: "the very first requirement in a Hospital (is) that it should do the sick no harm" (Nightingale, 1863). But with public awareness of widespread adverse events in healthcare today, this social contract is under pressure and must be renegotiated. Here, the medical drama serves as a way for the public to renegotiate the contract by presenting a different requirement for hospitals, namely that hospital staff are required to learn from error and harm. The common representation of medical mistakes in MTDs is thus indicative of a social contract where the public tolerates medical adverse events, on the basis that healthcare is perceived as continuously improving and healthcare professionals as constantly learning.

The introduction of this article presented medical studies that assume that representations of malpractice on television skew public perception of healthcare. However, the analysis and discussion of this article point to a crucial cultural function of presenting

images of medical error on television. Although researchers scuff of portrayals of non-compliance, such images should not be understood as "misinformation", but rather as reinforcements of trust in doctors, who are presented as doing their absolute best. Neither are images of medical error "distortions" of healthcare since real healthcare is ridden with error, but rather a way of making sense of continued failure in an important societal institution. Focusing only on portrayals of adequate technical skill in MTDs inevitably leads to an idealised portrayal of healthcare and a blindness towards a public that is eagerly consuming images of medical error as entertainment. Instead, investigations of healthcare fictions must include the experiential dimension of dramas – that is taking into account how something appears to the viewership. Famously, media theorist McLuhan (1964) described the TV medium as a "natural fit" for entertainment about doctors and nurses because the visual medium gets people involved in the experience of characters, including their bodily experiences and their thoughts. McLuhan predicted that MTDs would come to dominate television because of its ability to portray embodied experience more than any medium that came before it: "the TV image, in fostering a passion for depth involvement in every aspect of experience, creates an obsession with bodily welfare" (McLuhan, 1964). The point is that the medium of television will allow only certain types of messages to pass through – "the medium is the message" was McLuhan's famous thesis. In this sense, not all aspects of a healthcare practice can pass through the television screen (i.e., television can't realistically portray compliance with all hospital guidelines), but primarily experiential aspects of care. In the case of medical errors, what passes through the television screen is medical errors due to human factors rather than technical skills and the reassuring myth of a just world where medical errors are redeemed through improved care and learning healthcare professionals.

6 Conclusion

In the qualitative analysis of three error-themed episodes of popular medical television dramas, it is found that medical errors play a crucial role in moving the plot forward. The flying syringe of *Scrubs*, the nicked heart of *Grey's Anatomy* and the trial-and-error diagnosis of *House* are all mistakes that serve as points-of-no-return for the characters and

sets the plots in motion. In this way, errors are understood as events that create meaning and lets characters reflect on their role as a doctor or the identity of a disease. Errors appear to viewers as meaningful information about characters and plot lines. Error reveals something; a character trait (e.g., Dr Dorian's newfound courage in *Scrubs*), a relationship development (e.g., Dr Grey's and Dr Burke's mutual respect in *Grey's Anatomy*), or a mystery clue (e.g., information on diseases in *House*). Because medical errors are experienced as a driver of narrative, the audience expects error to lead somewhere. In this way, medical errors are not meaningless events but are always significant. Usually, this meaning of error leads to some form of justice for the adverse event, that is, the error is justified because it leads to an important development in the drama. This framing of medical error is unrealistic. Most often, healthcare errors do not carry meaning and do not lead to improvements in care, but instead to increased harm and costs. However, the portrayal of errors as meaningful events makes sense as a way for the public to retain trust in failing healthcare institutions. With public awareness of widespread errors in healthcare today, trust in healthcare is under pressure and requires a reformulation of the original social contract of healthcare, stating that hospitals should do the sick no harm. Here, the medical drama presents to the public a different requirement of hospitals, namely that trust can be retained if hospital staff continuously learn from adverse events.

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Article B: Integrating cognitive ethnography and phenomenology: rethinking the study of patient safety in healthcare organisations

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Integrating cognitive ethnography and phenomenology: rethinking the study of patient safety in healthcare organisations

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Abstract

While the past decade has witnessed a proliferation of work in the intersection between phenomenology and empirical studies of cognition, the multitude of possible methodological connections between the two remains largely uncharted. In line with recent developments in enactivist ethnography, this article contributes to the methodological multitude by proposing an integration between phenomenological interviews and cognitive video ethnography. Starting from Schütz's notion of the *taken-for-granted* (*das Fraglos-gegeben*), the article investigates a complex work environment through phenomenological interviews and Cognitive Event Analysis, drawing on distributed cognition and embodied cognitive science. The methodological integration is illustrated through the study of an adverse event in a highly specialised medical ward. Starting from a nurse's task of administering medicine to a patient, the analysis tracks how a distributed cognitive system in the ward handles an adverse event where a pill becomes contaminated. The analysis demonstrates how complex decision-making processes depend on agents' micro-scale embodied coordination, on their engagement with the material environment, and their anticipation of other agents' intentions. It is concluded that ethnography can accommodate both cognitive and phenomenological research aims, while also contributing to the important mission of understanding successful responses to adverse events in healthcare. The article further contributes to patient safety studies by demonstrating how safe medicine administration itself can lead to increased risk, hereby pointing to a problem of incompatible safety logics as a source of medication errors in healthcare.

Keywords Cognitive ethnography · Phenomenological interview · Qualitative methods · Distributed cognition · Adverse event · Health research

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1 Introduction

This article argues for an integration of cognitive and phenomenological methods for qualitative investigations of human error in professional contexts, particularly in complex environments with a low tolerance for error. The article presents ethnographic data from such an environment, namely a specialised hospital ward in Denmark, which is a *high-reliability* environment where adverse events can have fatal consequences (Reason, 2000). Hospitals are subject to constant changes, not only in patient-flow and staff composition, but also in technology, guidelines, and knowledge (Plsek & Wilson, 2001), and they are therefore prone to human error (Weingart et al., 2000). We argue that to understand the practices that may lead to human error in complex settings, a research method of participant observation must capture both system functionality of the organisation at hand, as well as the sense-making and experiences of organisational members. The former is a cognitive aspect of complex work, and the latter is a phenomenological aspect. Accordingly, we argue that an exhaustive understanding of work complexity cannot be achieved solely by cognitive methods for studying the functional organisation of work, nor solely by phenomenological methods for understanding practitioners' experience. Rather, it requires an integration of such methods. Although we discuss how such an integration can benefit healthcare, the goal of the article is to demonstrate the research value of an integrated methodology on a particularly clear example of hospital response to an adverse event.

An adverse event is, by definition, a deficiency in the planned and intended functioning of an organisational system (Pham et al., 2012). However, reports on adverse events, in general, tend to highlight what should have been done rather than on what was actually done and attended to by organisational members in situ. How healthcare professionals made sense of the situation is rarely given the attention it deserves (Dekker, 2015). A singular focus on how the system *ought to* function is problematic because little or nothing can be learned from what people *should* have done. Measuring real-life activities against systemic rationality, attributed to the system after the fact, always leaves human agents with the short end of the stick. Rather, adverse events (be it erroneous actions or failure to pick up relevant information) must be understood as how habituated bodies (Roth, 2018) enact in-the-moment intentions and in-order-to motives, in an environment that offers various affordances for action. While errors must be functionally defined, they are also experiential and based on intentions (Reason, 2000). On the other hand, if events in healthcare practices are purely approached from the perspective of in situ experiences, we would have no criteria for assessing whether an error occurred or not. As Roth (2018) observes, when the cockpit crew in the GE235 flight disaster turned off the left engine because the right engine was on fire, it was an error, no matter how the pilots experienced or made sense of the situation. Accordingly, we argue for a method that accommodates a dual perspective on adverse events, that is, a method where errors in organisational systems are identified using cognitive-functional analysis and criteria, but where the focus is on the participants' situated sense-making and embodied cognitive activities.

For this investigation, the dual perspective means adopting a research principle from cognitive science: we take a starting point in the identification of the so-called *functional system*, defined as a constellation of structures, internal and external to humans, conjoined to solve a given task (Hutchins, 1995b, 281). To complement this systemic-cognitive perspective, we explore the embodied, sense-making activities involved in how human agents enact such a functional system. In particular, we focus on behaviour that leads to (or prevents) adverse events and simultaneously goes unquestioned by organisational members. Alfred Schütz (1967, 36-7) called this dimension of experience the *taken-for-granted* – an already constituted meaning-structure that is presupposed and left out of intentional awareness. Schütz argues that the exposure of what is currently taken-for-granted in an organisation requires a pragmatic interest in the organisation at hand:

> The taken-for-granted (*das Fraglos-gegeben*) is always that particular level of experience which presents itself as not in need of further analysis. Whether a level of experience is thus taken for granted depends on the pragmatic interest of the reflective glance which is directed upon it and thereby upon the particular Here and Now from which that glance is operating. (…) a change of attention can transform something that is taken for granted into something problematical (Schütz, 1967, 74)

In other words, certain experiential structures only reveal themselves in relation to a specific problem in concrete practice. In our case, we identify the problem as adverse events in hospitals, specifically medication errors. To reveal the taken-for-granted structures concerning medication errors, we take the case of a seemingly simple and easy task. Not only is a simple task more illustrative of our method, but it also highlights how seemingly easy tasks can become complex when the course of action deviates from the norm in complex environments. Another advantage of taking a starting point in a simple task is that it simplifies the identification of such deviations for non-experts.

Our starting point is the very mundane medicine-related task at a hospital ward; a patient ingesting a pill. Administering pills is a task with an easily defined goal: getting the prescribed medicine correctly from the medicine room to, and indeed into, the patient. Based on our ethnographic fieldwork, the task process is equally simple: 1) A doctor makes a prescription based on a diagnosis; 2) a nurse locates the doctor's prescription, dispenses the pills in the ward's medicine room and brings them to the patient; and 3) the patient ingests the pills. This simple process is enacted countless times each day in the ward. Much research into adverse events focuses on the first two steps in the process because they are prone to a large number of medical errors (Pham et al., 2012): wrong medicine is prescribed, wrong dosages are dispensed, known allergies are missed, etc. On the other hand, step 3 of the process, having the patient ingest the pills, is rarely mentioned in the literature, maybe because it seems straightforward in comparison with prescribing and administering drugs. Based on these reflections, we will analyse a case where a patient has to ingest a full medical dispensing cup of pills and accidentally drops a pill, for which reason a replacement pill has to be found.

In section 2 below, we elaborate on our methodological integration of cognitive ethnography and phenomenology. In section 3, we apply the methods to the case of the dropped pill, analysing task micro-interactions and interpreting the subjective elements involved. Section 4 discusses the application of our integrated methodology including benefits and limitations for hospital practice. Section 5 is a short conclusion.

2 Cognitive and phenomenological methods

To achieve a dual perspective on organisational practices, we juxtapose cognitive and phenomenological considerations with a starting point in cognitive ethnography. This approach parallels previous attempts at doing ethnography from an enactivist perspective. Notably, Legrand and Ravn (2009, 395) show that the researcher can enter a "somatic mode of attention" where ethnographic interviews are "developed into dialogues also characterised as 'the active interview'". Further, Kirmayer and Ramstead (2017) use ethnography to study cultural diversity concerning psychopathology; Yatczak (2019) investigates selfhood in people with Alzheimer's disease as it is mediated through the use of everyday objects; Høffding (2018, 42) investigates musicians' experiences through an "ethnographic interview"; Jing and Ravn (2018, 390) "use an interweaving of phenomenological explorations and ethnographical methods" for understanding dancer experiences; and Hjortborg and Ravn (2019, 5) use "ethnographic fieldwork" to study experiential structures of tai chi. Our proposal is especially aligned with Hutchins (2010) and Briedis (2019) who both produce descriptions of organisational enaction from ethnographic observations and apply phenomenological concepts to these descriptions, although their specific methods, concepts, and research interests differ from this article.

Our specific take is also inspired by the two-tier structure of Høffding and Martiny (2016).[1] However, in contrast to Høffding and Martiny, our framework accommodates both interviews and video-ethnographic observation, as well as both cognitive and phenomenological analyses. *The first tier* of our process is the generation of ethnographic data, through cognitive video ethnography and through phenomenological interviews that elicit descriptions of how organisational members experience their work in general and specific work situations in particular. When doing cognitive video ethnography, "the cognitive aspects of the observed practice are revealed in the detailed micro-analysis" (Alač & Hutchins, 2004, 632), and therefore our *second tier* is an analysis of the ethnographic data using the method of Cognitive Event Analysis in combination with a phenomenological analysis. Through this integration, the cognitive analysis is illuminated by first-person data from the phenomenological interviews. Section 2.1 details the cognitive aspects of our method,

[1] In Høffding and Martiny (2016), the first tier of the phenomenological interview is the generation of interviewee descriptions of lived experience. In the second tier, the descriptions are analysed using phenomenological methods (Gallagher and Zahavi 2012, chap. 2) to produce generalized knowledge of subjectivity as such.

and section 2.2 explains the phenomenological aspects. As we assume that the readership is acquainted with phenomenological methods, we prioritise explaining the cognitive-ethnographic dimension of the methodological integration.

2.1 Cognitive ethnography and cognitive event analysis

Cognitive ethnography is a qualitative participant observation method building on the theory of distributed cognition (Hutchins, 1995a; Hollan et al., 2000; Giere & Moffatt, 2003; Kirsh, 2006; Sutton, 2006). Originating from the work of anthropologist Edwin Hutchins, it aspires to trace the specific distribution of tasks in a given cognitive system such as a medical ward. While many schools of ethnography insist on the independence of the ethnographic method from theory (Ball & Ormerod, 2000), cognitive ethnographers see a firm link between the epistemological paradigm of distributed cognition and methods for tracking how cognitive systems rely on cognitive resources throughout the environment. As a result of this close connection between theory and method, our first step of the analysis is to identify the "invariant task" (Hutchins, 1995b, 281) to be investigated below. The decision on which task to investigate is not solely the analysts. In our case, tracing the emergence of medical error in medication administration was decided in cooperation with hospital practitioners as co-researchers of the research project. We decided to track medicine administering because of its firm association with human error (Pham et al., 2012).

Another characteristic of cognitive ethnography is *verifiability* (Ball & Ormerod, 2000). In our case, verifiability is reached through transparent annotations of video-recorded micro-interactions (as exemplified in Figs. 1 and 2 below). For micro-analysis, we use Cognitive Event Analysis (CEA), which is a qualitative, observation-based method for studying cognitive events in human interactivity (Steffensen, 2013, 2015; Steffensen et al., 2016; Ball & Ormerod, 2017; Trasmundi, 2020; Cowley & Nash, 2013; Steffensen & Vallée-Tourangeau, 2018). Based on ethnographic video data, CEA focuses on the behavioural details of what we call a 'cognitive *event*', a concept denoting significant changes in the organism-environment system (Chemero, 2000). Here, CEA draws on radical embodied cognitive science (Chemero, 2009), which sees organism and environment as entangled. Accordingly, no cognitive feature can be ascribed to the organism alone but is always an aspect of the entire organism-environment system. This idea of events corresponds with systemic psychology (Järvilehto, 1998) and is also found in distributed cognition (Hutchins, 1995a, 2014), which takes a functional view on the cognitive system as "a constellation of structures, some of them internal to the human actors, some external, involved in the performance of some invariant task" (Hutchins, 1995b, 281). Distributed cognition maintains that cognitive processes crisscross the boundaries of brains, bodies, artefacts, time, and culture (Hollan et al., 2000) and it is this crisscrossing dynamic that the analysis seeks to understand.

To do so, CEA follows a methodological principle from systemic psychology, according to which "Research should start from the determination of the results of behaviour and lead to the necessary constituents of the living system determining the achievement of these results" (Järvilehto, 2009, 118). To track the results

of behaviour to its necessary constituents, CEA proceeds in five steps (Steffensen et al., 2016): 1) Cognitive event identification, 2) Event pivot identification, 3) Data annotation, 4) Cognitive trajectory segmentation, and 5) Cognitive trajectory analysis.

The first step of *Cognitive event identification* follows from the insight of Merleau-Ponty (1963), that all behaviour is a result of both here-and-now perceptions, the situated environment, as well as habituated bodies, an event is not a self-contained category but depends on an observer-dependent identification based on relevant cognitive criteria. Such identification can follow a theoretical classification (e.g., problem-solving, decision-making, planning), or it can build on organisational members' categorisations of their activities.

The second step in CEA is the *Event pivot identification*. Along the trajectory of the cognitive event, some changes define important phase transitions (occurrences, happenings, or actions), e.g., the pilots turning off the engine in case of the GE235 flight. These central points are termed *event pivots*, and the temporal distribution of event pivots along a trajectory constitute the overall cognitive event. If the event is a case of problem-solving, an event pivot is a transition from having a problem and no solution to having a solution and no problem. If the cognitive event is 'to diagnose', the event pivot is the moment when a doctor formulates a disease typology of the patient. Whereas an event is temporally extended (to diagnose takes time), an event pivot is a quasi-momentary transition between a before (still examining the patient) and an after (now starting treatment). Some events may rely on more than one event pivot. For instance, a primary event pivot could be solving a problem, while a secondary event pivot could be the identification of the problem to be solved.

Once the event and the central event pivots are established, CEA practitioners attend to the minuscule details of behaviour. For this third step, which is *data annotation*, most practitioners rely on a rich annotation of behaviour (verbal utterances, gesture, movements, gaze, etc.) and of structural properties of the task environment (e.g. the distribution of artefacts or measurements of important environmental features). The exact design of the annotation procedure depends on the research question and event identification (for details on annotation, see Steffensen et al., 2016).

CEA's fourth step is a *cognitive trajectory segmentation* based on the identified event pivots and data annotations. If the annotation categories have been carefully selected, a segmentation of the cognitive trajectory should correlate with distinctive behavioural patterns (i.e., with a unique constellation of annotations). With this step, we establish how a given cognitive result (say, a diagnosis) is enacted through preceding embodied behaviour.

From here we can move to the fifth and final step, *cognitive trajectory analysis*, which aims at establishing the salient links between the behavioural and functional properties of the cognitive event. Having identified the result, the guiding question is: "what were the enabling conditions for the cognitive result, and how was it achieved by the cognitive system animated by one or more living agents?" (Steffensen et al., 2016, 85). Careful analysis of how the cognitive system undergoes event pivots along a cognitive trajectory allows for establishing how intercorporeal

engagement with the world and with other agents allows cognitive agents to calibrate their cognitive systems and bring forth results.

In summary, CEA integrates the functional view of distributed cognition and the emphasis on embodied and intercorporeal dynamics, derived from embodied cognitive science (Anderson et al., 2012) and the study of human interaction (Streeck et al., 2011). CEA is a method that allows for a detailed retrospective analysis of the observable dimensions of events, as well as their enabling constraints. But as argued by Pedersen (2015, 250), "CEA *in itself* does not explain what makes an enabling condition an enabling condition" (cf. Trasmundi, 2020). Phenomenology is a candidate for providing such explanations, as it complements the functional analysis with an understanding of how behaviour emerges as moment-to-moment interaction and intentions (Fuchs & De Jaegher, 2009).

2.2 Phenomenological interview and analysis

Phenomenology plays a role in both our data gathering and data analysis. During the former, cognitive ethnography is scaffolded by in situ phenomenological interviews. Preferably, organisational members will be interviewed about their experiences during or right after events. This means that phenomenology cannot be an after-thought, but must be "front-loaded" (Gallagher, 2003) into the research design. We did experience that cognitive video ethnography and phenomenological interviews could become mutually exclusive, as the first primarily involves shadowing the work with a video camera and the second having an active dialogue. Our recommendation is to communicate to subjects that questions will be asked both during their work and after significant work events. As Urban and Quinlan (2014) suggest, it does require spending time in the ward and becoming sufficiently acquainted with routines before questions can be asked naturally. Without such preparations and a researcher attitude of patience, the phenomenological method can become disruptive to working subjects.

We treat the method of phenomenological interviewing rather superficially here, as it has been well covered before (see also Zahavi, 2019). The aspiration of doing phenomenological interviews is reaching the pre-reflective experiences of the interviewee. The interviewer aspires to establish a first-person understanding of how the interviewee makes sense of their work. We approach interviewees with an open-ended questioning style that prompt pondering of work interactions that relate to our research interest. Thus, with a starting point in principles from Høffding and Martiny (2016), we interview nurses and doctors about interactions concerning medicine administration with attention to details of their bodily experiences and engagement. One way of achieving that attention is through reiterated 'how do you…' questions that prompt the interviewee to re-live the interaction in dialogue with the interviewer.

In the second phase of our investigation, phenomenological interviews and cognitive analyses are subject to a phenomenological interpretation. Thus, we do not only analyse the phenomenological interview transcriptions; we also contrast interview

data with our annotated video data. As tools for analysing, we use several phenomenological theoretical concepts for understanding medical practice (as proposed by Zahavi, 2019) along with *eidetic variation* and *intersubjective corroboration* (Gallagher & Zahavi 2012, 29–31) for validating our analysis. The two concepts refer to using our imagination to vary and subtract our analysis until we find essential aspects and also to check and validate these essential aspects with medical staff and fellow researchers. We are also inspired by Hutchins's way of interpreting cognitive ethnography data using phenomenological concepts, leading to descriptions of what he calls "enactment of phenomenal objects" (Hutchins, 2010, 438).

3 The case of the dropped pill: An analysis

The following analysis explores the response to an adverse event in a hospital ward. The analysed task, as presented in Section 1, is that of having the patient ingest his medication. However, in this case, the task changes, as the patient accidentally drops the pill on the floor, so it becomes contaminated. From this adverse event, an embedded task emerges, namely that of replacing the pill with an uncontaminated one. Only when this task has been solved, can the original task be solved. Given the overall CEA methodology, two patterns are important in our analysis of the adverse event: how the cognitive system reacts when an adverse event occurs, and how it executes the relevant countermeasures in response to the adverse event. These two patterns will be analysed and discussed in Section 3.1 and 3.2, respectively.

3.1 Task emergence

The case begins early morning in a highly specialised medical ward in Denmark. The first author is shadowing the work of a male nurse (anonymised as 'Ryan'). Ryan is taking care of an elderly male patient (anonymised as 'Hal') with a stomach infection, respiratory problems, and diabetes. Hal is delirious and speaks of dolphins swimming around in his visibly distended abdomen since he adversely received a double dosage of sleeping drugs during shifts. In his delirious state, he has taken several bad falls and bumped his head badly trying to get out of bed this morning. These preceding adverse events happened before the researcher entered the ward and were therefore captured anecdotally. During the morning medication rounds, Ryan hands out a small medical dispensing cup full of pills to Hal and observes while Hal ingests the pills. However, one pill slips Hal's mouth and falls to the floor. This is an adverse event because the pill is now considered contaminated by hospital regulations, and Hal does not receive the full amount of the prescribed medicine. While the dropping of the pill was not caught on camera, because the camera focused on Ryan's work, Fig. 1 illustrates Ryan's immediate reaction after Hal drops the pill: He notices that Hal has dropped the pill on the floor, and he moves the tray table away to find the pill (1a). He then ducks in front of Hal (who follows him with his gaze) and seizes the dropped pill (1b). He places it on the tray table in front of Hal, and

he inspects it visually for 15 s (1c). Hal asks, "was it the one I dropped there" and reaches his hand towards the pill as if to grab it (1d). As Hal physically reaches out for the pill, Ryan quickly shields the pill (1e) with his right hand and pushes it a few centimetres away from Hal (1f).

Hal's pill dropping prompts the cognitive system to reconsider the course of action. The system enters a state of a "suspended next" (Steffensen & Vallée-Tourangeau, 2018), that is a situation where "the lack of experience-based solutions forces the agent(s) to (…) search the problem space to come up with possible solutions" (Steffensen & Vallée-Tourangeau, 2018, 175). The suspended next last for 41 s until Ryan formulates the solution: "Shouldn't I find you a new one. One that hasn't been on the floor" – the formulation of this solution is the primary event pivot. Accordingly, the 41 s between the two event pivots function as a decision-making event that prompts us to ask: what conditions this specific decision to be reached? Why does it become taken-for-granted that Ryan should find a replacement?

As Fig. 1 show, the cognitive system proceeds through five phases that cascade into the final decision, which Ryan utters in phase VI, immediately following the event pivot). At first glance, Ryan's decision seems to follow from a conversational focus on the identity of the pill in phase IV and V:

> **Hal:** Was it one I dropped there?
> **Ryan:** It was one you dropped, but shouldn't I find you a new one. One that hasn't been on the floor.

However, a closer look at the embodied dynamics throughout the five phases reveals that Ryan's decision is constrained by a change of focus in the cognitive trajectory. This change becomes clear when we inspect the cognitive trajectory because it shows a striking asymmetry between the two participants. Ryan's actions throughout phase I-III are quite straightforward: in phase I, he changes the layout of the room by moving the tray table, allowing him to have an overview of the floor so he can see the pill. In phase II he ducks to pick up the pill, and in phase III he spends 15 s visually inspecting the pill on the tray table, presumably to determine if he can immediately identify the dropped pill. However, the pill is generic and not identifiable.

While this course of action pertains to Ryan's professional vision (Goodwin, 1994), each of these steps affects Hal's perception of the situation. First, Ryan's unusual bodily movement as he ducks to the floor, makes the pill a point of attention, that is, whereas it slipped into the periphery of Hal's attention, Ryan's movement redirects his attention to the pill. Second, when Ryan places the pill on the tray table, the changed position of the table means that the pill is right in Hal's line of vision. Third, Ryan's intent inspection of the pill makes it a distinctive dialogical affordance for Hal. Accordingly, as we reach phase IV in Fig. 1, Hal is prompted by Ryan to *act* on the presence of the pill. On a verbal level, Hal's utterance ("was it one I dropped there?") seems to focus on the *identity* of the pill. However, as he asks this question, he moves his right hand forward towards the pill. Thus, he seemingly attempts to finish the task of ingesting the pills that was suspended at the secondary event pivot. From the perspective of Hal's habituated body, that of a layperson and delirious patient, this action is meaningful, as he is not encultured into the hospital

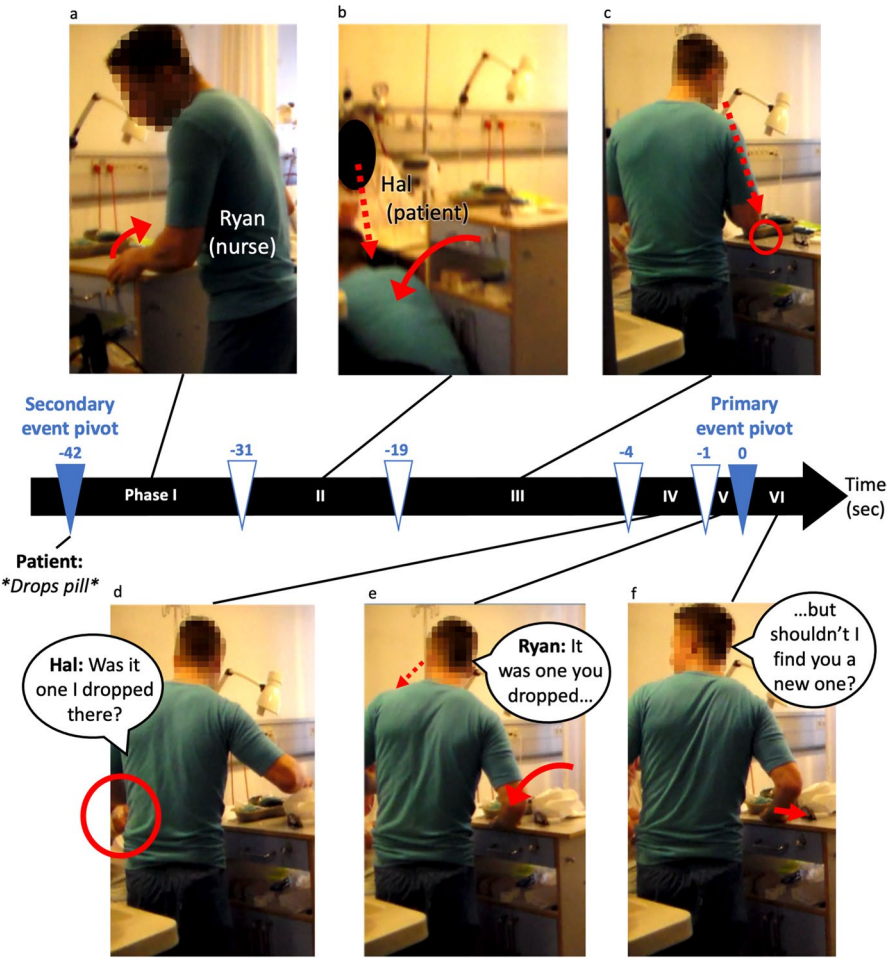

Fig. 1 The dropped pill. The timeline shows the key moments when the patient drops the pill and Ryan picks it up. Solid arrows indicate bodily movements; truncated arrows indicate gaze direction; circles indicate points of interest from an analytical perspective. The triangles on the cognitive trajectory indicate event pivots (blue triangles) and phase transitions (white triangles), as discussed in section 2.1

staff's categorisation of sources of contamination. But Ryan is. While the first half of his response ("it was one you dropped") pertains to the verbal aspect of Hal's question (i.e., it focuses on the identity of the pill), his embodied behaviour responds to Hal's attempt at resuming the ingestion of the pill. Thus, Ryan covers the pill with his hand to shield Hal from it, and he further moves it slightly away from Hal.

In conclusion, Hal's reaching out for the pill significantly changes the cognitive trajectory, and Ryan's decision to find a replacement is not merely a reaction to the fact that Hal dropped the pill. Rather than following an (unwritten) norm at the ward, according to which a dropped pill is thrown away, Ryan honours Hal's unarticulated wish to finish the intake of the medication. In line with CEA's focus

on distributed cognitive systems, we can thus conclude that the decision to seek a replacement pill is not made by Ryan in isolation; it is shaped by the material and actional dimensions of the entire cognitive system consisting of patient, nurse, tray table, and pill – as well as cultural norms and situated behaviour.

In a phenomenological analysis of the interaction in Fig. 1, it might first appear taken-for-granted that the dropped pill should be replaced with a clean one. However, as we have shown with CEA, this decision is constrained by several environmental factors – the location of the tray table, the generic-looking pill, etc. – as well as intersubjective factors, including the curiosity of Ryan and Hal into the identity of the generic-looking pill. These constraints go beyond the immediate interaction in Fig. 1, as both Hal's and Ryan's actions are constrained by previous events, most notably the double dosage error that happened to Hal during the night. Hal's experience is visibly still under the influence of sleeping medication, which appears to have lowered his situational awareness. For example, he fell twice while trying to get out of bed in the morning, and in Fig. 1 he attempts to grab the pill, not being mindful of how the floor might have contaminated it. Ryan's attention is also influenced by the adverse event: Ryan explains later that Hal "is somewhat confused today and he has also received double up of Zonoct (a sleeping drug) last night", and then adds "we have to see (…) if we can shield him today." Using the idiom of 'shielding', Ryan indicates that special attention should be on protecting Hal. This protective framing of Hal's situation saturates the interaction, as Ryan literally shields Hal from the pill (Fig. 1e), and thus from further adverse events.

In an intersubjective corroboration (Gallagher & Zahavi, 2012, 31) of our analysis, several other nurses were asked what they do if and when pills are dropped to the floor. A common answer was akin to "sometimes I just throw out the pill if I can't recognise it and I consider it non-vital". Although it is a rule that dropped pills should be replaced, these answers suggest that it is unusual to replace dropped pills – simply because it happens too often and can take away valuable time from other tasks. Consequently, local circumstances must make our case special: the intersubjective mood (that of shielding the delirious Hal from further adverse events), and the specific affordance layout as shown in Fig. 1, bring forth the plan to replace the pill. The decision to find an uncontaminated pill cannot be attributed to Ryan but happens as a result of the interaction within an intersubjective relation of patient-nurse, as both agents are part of the situation when the pill possibly becomes contaminated. Although Hal is under the influence of sleeping medication, he is still making some sense of the situation in which the pill is dropped and the nurse ducks in front of him. Hal strives to make sense of the pill, partly in terms of its identity, partly as it becomes an affordance for finishing the intake of medication. The fact that Hal is included in the situation as sense-maker changes the meaning attributed to the situation: it becomes important to find a replacement pill.

A final factor of this phenomenological analysis is the role of the researcher. As the researcher is present with a video camera, he is a candidate for becoming a part of the distributed cognitive system (Steffensen, 2013). The researcher presents a gaze from the outside, and Ryan knows that the researcher is studying human errors, just like he knows that the researcher is aware of the adverse double dosage that Hal received during the night. Ryan's awareness of the researcher's attention and

interests may potentially transform the researcher from merely an observer into a factor that influences the decision to replace the pill. The presence of the video camera might not be conducive for chucking the pill, and the awareness of the researcher's interests might have prompted Ryan to demonstrate how adverse events are handled. We have, however, not been able to interview Ryan post hoc on his perception of the researcher's presence in the situation.

3.2 Task execution

In this section, we investigate how the problem of finding an uncontaminated replacement pill is solved in the medicine room. The interaction takes place as Ryan steps into the medicine room 20 min after Hal dropped the pill. The medicine room is locked and can only be opened with a staff ID card. When Ryan enters the room, a female nurse (anonymised as 'Alba') is already in the room, dispensing drugs for another patient. The medicine room is equipped with cupboards and storage for medication, a long table at which the nurses can dose the medication, and two computers where information on medication, as well as each patient's medication list, can be retrieved. A sign on the door says "disturbance-free zone", as it is a managerial policy that staff should keep conversation to a minimum in the room, in order to prevent medication errors.

As established in the previous section, the task at hand is to find a replacement for the dropped pill. Forestalling the event segmentation, this task falls into three subprocesses: *configuration*, *selection*, and *validation*. 'Configuration' refers to how the distributed cognitive system is set up to identify the pill; 'selection' is the process of narrowing down the potential replacement pills to the correct one; 'validation' is the process of ascertaining that the selected pill is in fact and beyond doubt identical to the one Hal dropped. In this section, we demonstrate how each sub-process conditions the following ones.

It is a foundational assumption in distributed cognition that cognition comprises both human agents, material artefacts, and sociocultural resources (Hollan et al., 2000). Manipulating these elements is a crucial way of administering cognitive processes, for instance, to bring in needed people or to rearrange artefacts. This is what we refer to as a *configuration* of the system.

Immediately after Ryan has entered the room, we notice that he reconfigures the cognitive system to include Alba. He picks up the dropped pill, shows it to Alba, and asks with a grin: "Can you find this one?" Looking at the generic white pill, Alba laughs and retorts: "No, I can't!" It is quite obviously a joke, though the exchange between the two has the crucial function of turning Alba into a *potential* member of the cognitive system, as the joke has made her aware of Ryan's task. As we shall see, she will become increasingly involved during the next two phases. Other resources are also included. Ryan places the dropped pill on a piece of paper towel, and while that prevents the pill from contaminating the table, it further has the epistemic function (Kirsh & Maglio, 1994) of background texture for visual comparison of pills (cf. our recount of the validation phase below). Other resources included in the

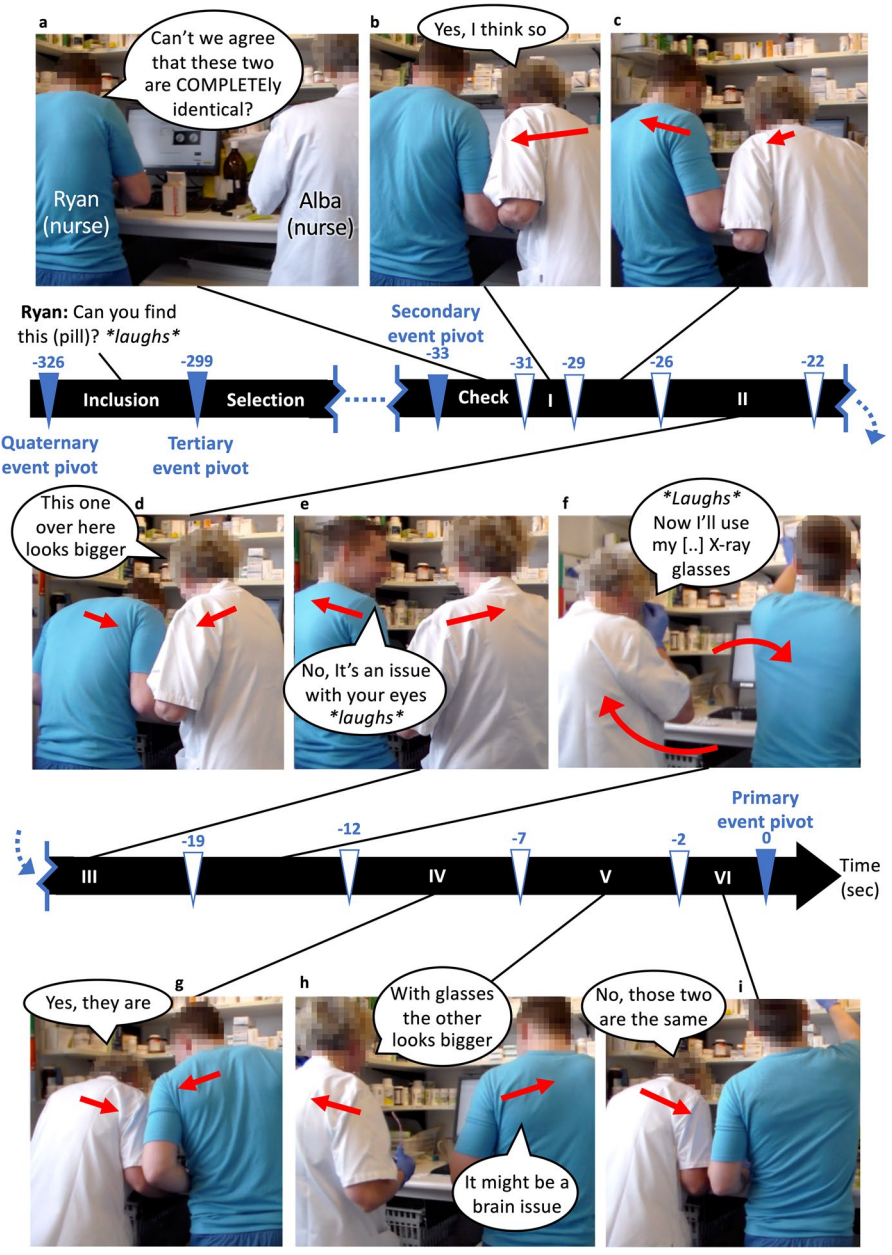

Fig. 2 Replacing the dropped pill. The figure shows the interaction of Ryan and Alba when they compare the size and shape of the contaminated pill and its replacement. Solid arrows indicate movement. Speech bubbles indicate the nurse's talk during the event

cognitive system are the patient's digital medicine list and the medicine database with images of pills. As he embarks on his task, Ryan places these two resources side-by-side on the computer monitor.

In the configuration phase, Ryan functions as the "main cognizer" (Galosia et al., 2010), and he sticks to this role in the *selection* phase. First, he begins to compare the dropped pill with screen images of pills from the medicine database. Hal's medicine list is long, so Ryan compares the pill with pictures of numerous candidate pills.[2] By comparing the dropped pill on the paper towel with images of pills from the medicine database and the medicine list, Ryan eliminates most of the drugs on the medicine list, until he has narrowed down the list to only two possible candidates that both look similar to the dropped pill – both white and round. Ryan cannot decide which one of the pills is the correct one, but because he has made Alba a potential member of the cognitive system, he can now activate her by uttering his doubt: "I'm not a hundred per cent sure if it's this one." In response, Alba suggests opening the pillboxes of the two candidate pills, allowing for a physical comparison: "You know what you could. Sometimes I simply just unpack one and sacrifice it (i.e., throw it away if it is not identical)." Ryan follows this advice, and after opening two pillboxes, he decides on a pill that looks identical to the dropped pill. He places the candidate pill on the paper towel, side-by-side with the dropped pill and asks Alba for validation.

Figure 2 is our annotation of the *validation* phase, showing how the cognitive event passes through five validation checks. The first check starts when Ryan asks Alba to confirm that he has found the right pill: "Can't we agree that these two are COMPLETEly identical?" (2a). Alba moves closer to inspect the two pills, and she immediately agrees that "Yes, I think so" (2b). Alba takes an even closer look at the two pills (2c), moves back again, and concludes: "when standing here I think this one over here looks bigger" (2d), thus suggesting that the two pills are *not* the same drug. The nurses check the pills again and Ryan concludes with a smile that "No, that's an issue with your eyes" (2e). As Ryan puts back the medicine packages, Alba laughs and says, "You know what, now I'll put on my glasses, my x-ray glasses, then I'll finally be able to see something" (2f). They then move in close and compare the two pills again, and Alba concludes: "Yes they are (identical)" (2 g). Ryan answers "they are entirely the same." Alba still hesitates to trust her vision though: "Yes they are, but you know what, when I put on my glasses, I think this other one looks a little bigger. No, I think they are (identical)" (2 h). Ryan jokingly comments on her indecisiveness: "it might be a brain issue." Finally, Alba inspects the pills a last time, before she ends the event by concluding: "No, those two are the same" (2i). This confirmation shows that a solution has been reached. The nurses have passed through five visual checks before reaching consensus, which is the primary event pivot.

[2] In the selection process, Ryan consults Alba multiple times, thereby creating a closed-loop between the selection and the validation because Alba falsifies candidate pills during the selection. For reasons of length, we do not analyse this specific dynamic in detail.

Interpreting the sequence, we notice that the exchange is characterised by the dialogical collaboration between the two nurses despite the "disturbance-free zone" sign on the door to the medicine room. At the follow-up phenomenological interview, Ryan explains his experience in the medicine room:

> **Researcher:** Why does it say out there in the medicine room that it has to be free of disturbances? Who decided that?
> **Ryan:** It is actually because we don't want relatives and others to disturb in there. It's to avoid mistakes from happening. Precisely because you can see that the more disturbances that happen during medicine dispensing, the bigger the risk of mistakes.

Although Ryan experiences the disturbance-free zone as a preventive measure against interruptions from patients and relatives, he is still aware of the danger of disturbing Alba and other colleagues. For him, though, the medicine room is also a collegial space:

> **Ryan:** I mean **lowers voice**, sometimes you stand out there (in the medicine room) and talk purely private out there **raises voice again**. Sometimes it's like a haven, where you can be sure you will not be disturbed by patients or relatives.
> **Researcher:** **Laughs** Yes, because it's unlocked everywhere else.
> **Ryan:** Yes, exactly. That and the toilet are probably the only spaces, where you- **laughs** where you can ventilate. Also, if you would like to be a bit collegial. So, it's pretty much out there (in the medicine room) that is the only space.

In Ryan's experience, the medicine room is a "haven" and can, therefore, be a space for dialogue and jokes. We have shown in the analysis that it is precisely the dialogical inclusion of Alba that enables the solution to the problem of validating the replacement pill. If the 'no-interruption'-rule were strictly enforced, it would rule out the specific reconfiguration of the cognitive system (Ryan could not casually include Alba), potentially obstructing the task at hand. Thus, the solution is brought forth by the nurses' intersubjective experience of the medicine room as a space for cooperation. Furthermore, the dialogue in the medicine room is not only task-related but also 'collegial', as Ryan calls it. Thus, it seems to be a central function of informal team interaction to secure the team members' availability, which allows for reconfigurations of cognitive systems.

From an ecological-enactive perspective (van den Herik, 2018, 2020), the nurses' utterances function as *attentional actions* that guide the agents in finding an uncontaminated replacement. Their utterances become a way of modifying and constraining the perception of the environment, as they highlight certain aspects of reality that should be paid special attention to. For instance, in the selection phase, Ryan specifies relevant tactile-visual dimensions when he utters that some pills are too "flat" or too "thick." Likewise, Alba expresses doubt by describing one pill as "bigger" than the other in the validation phase. These expressions index the parameters for the perceptual work that can be performed

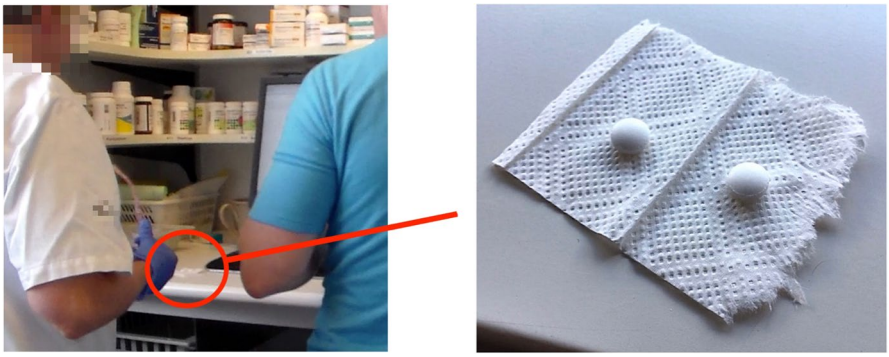

Fig. 3 The paper towel texture pattern provides an intrinsic scale for comparing the size of the pills. If the pills cover the same amount of ground texture, they appear to be the same width. The image on the right is a reconstruction using a paper towel from the actual ward, obtained 17 months after the event

(Goodwin, 1994). Linguists use the term *languaging* to describe such constraints on what is a possible solution to the task (Cowley & Kuhle, 2020); in this case, a solution that focuses on the pills' sameness in size and shape, rather than, say, their texture or weight.

As languaging "is a mode of organization that links people with each other, external resources and cultural traditions" (Cowley, 2011), it only makes sense when integrated with how agents perceive their environment. This link comes to the fore in how the nurses establish that the two pills are "the same" by indexing relevant visual constraints. However, the function of such constraints depends on their visual perception. In his classical work on ecological perception, Gibson (1979) scrutinises such issues in great detail (cf. Gallagher & Zahavi, 2012, 230). Gibson (1979, 164) points out that visual perception happens through a "reciprocity between observer and environment." Perception relies on horizon and background, and this is especially important when trying to determine the size of two objects since the texture of the background surface provides an intrinsic scale for comparing object size.[3] If the surface texture is equidistant, equal amounts of texture correspond to equal stretches of distance along the ground. This is where the paper towel, on which Ryan has placed the pills, becomes important. The texture of the paper towel provides a scale for determining if the two pills are the same size. As illustrated in Fig. 3, the pattern of the paper towel varies, and hence the comparison of the pills depends on where the pills are placed on the paper towel: if one is placed within the diamonds, and the other on the diagonal lines, a comparison is more difficult than if both are placed within diamonds. The nurses' visual comparison is thus a qualified estimate that depends on ambient factors such as ground texture.

Phenomenologically, the solution to the task in the medicine room depends on how the nurses perceive their work: we have shown that the nurses perceive the

[3] This is well-known from optical illusions that use distortions in the background to trick the perceiver into seeing something as bigger or smaller than it is.

Fig. 4 Ryan hands Hal the pill and hereby executes the task of administering medicine

medicine room as a "haven" where they can talk freely. They use utterances to constrain the possible solutions to their problem, specifically by narrowing the solution to the size and shape of the pills rather than other factors. Thus, the nurses provide a validation of the pill that is based on a visual estimate dependent on ambient factors such as the texture of the paper cloth on which the pills lie. In this way, intersubjective and environmental factors alike constrain how the cognitive system brings forth a solution in the medicine room.

As an epilogue to this analysis, we take a look at what Ryan does after he has found the replacement pill. In Fig. 4, we see Ryan handing the pill to Hal followed by Hal successfully ingesting the pill. The task of administering medicine is now finalised and the adverse event has been successfully countered. Again, we notice how Hal shows interest in the identity of the pill:

> **Ryan:** Here's that last pill. Yes, it was the one you dropped. I was down and got it.
> **Patient:** So, which one was it I dropped?
> **Ryan:** It was the one called (medication name)

Concluding our analysis, the pill has become what Merleau-Ponty (1963, 162) calls a *use-object*, that is an object endowed with meaning based on the *perceived situation* and intentions of the actions of other subjects (see also Thompson, 2007, 76–77). From the moment Hal stretches his hand forward and Ryan perceives his action as an attempt to grab the dropped pill (Fig. 2e), the perceived situation for Ryan's work is founded in his perception of Hal's interest in the pill. If it was not the case that Ryan perceived Hal's intention as grabbing the pill, the adverse event

might have been resolved with the pill being quickly discarded and Hal not receiving his remaining pill. In this way, the functional dimensions of cognitive systems at work cannot be separated from how agents perceive and make sense of the work in question. A nurse's perception of a patient's intentions can make the difference between an adverse event being successfully captured and not being captured.

4 Discussion and applicability

Our analysis showed that Ryan, as part of a cognitive system, weighs several environmental and intersubjective factors in order to solve the replacement task successfully. Should the pill be replaced even though it would take time and increase the risk of giving a wrong replacement? Should Alba be included in the task although it would disturb her medicine administration? And should the replacement pill be administered to Hal although Ryan could not be entirely certain that the pill was identical to the dropped pill? All these decisions required an implicit weighing of cost against benefit (Kirsh, 2006).[4] Although we cannot calculate if it was worth it to find a replacement pill, we do know that Ryan had to make decisions on these trade-offs. His decisions were based on environmental and intersubjective factors such as Hal's interest and his collegial attitude towards Alba. Within these constraints, Ryan made numerous attempts to provide a safe replacement process, especially by including an experienced colleague for support and validation. On the other hand, Ryan's insistence on safety did also lead to increased risk for other agents, i.e., the increased risk for medication errors in Alba's work and the increased risk of adversely giving Hal another double medicine dosage (if the replacement pill turned out to be the wrong one). The clearest example of the increased risk following Ryan's decisions was perhaps the bending of the 'no-disturbance'-rule to increase the safety of the visual validation of the replacement pill.

We have thus identified a conflict of aims between ensuring safety on a local, task-solving scale for Ryan on the one hand, and maintaining safety on an institutional scale on the other. In this case, the goals of a local safety logic of dialogical validation and intersubjective intent, versus the formal safety logic of having a no-interruption zone, are incompatible. Safety researchers have found such conflicts of goals to be a prevalent source of errors of everyday work, and argue that identifying and monitoring such conflicting goals are therefore of utmost importance for safety (Bergström & Dekker, 2014). Our investigation confirms that the risk of everyday adverse events stems from conflicting goals in an organisation trying to cope effectively with the complexities of its structure and operational environment:

> The processes that normally help assure safety and generate organisational success (risk assessments, operational trade-offs) can also be responsible for organisational demise: failure incubates non-randomly, opportunistically

[4] We are grateful to two anonymous reviewers for pointing out these issues of cost-benefit.

> alongside or on the back of the very structures and processes that are supposed to prevent it (Dekker & Pruchnicki, 2014, 541).

This is Ryan's dilemma. By doing his work responsibly and safely, Ryan simultaneously had to expose the system to increased risk. He did himself become exposed to the *sharp end* of the healthcare system (Hughes, 2008). Such conflicts have been described as a "tension between health agendas and staff routines "(Brown & Reavey, 2017, 9) and "a tension between the linear logic of forecasted action and the fuzzy logic of practice" (Ernst, 2016, 111). In these situations, healthcare staff has to reconcile conflicting demands. They must find a 'third way' out (Ravenhill et al., 2020, 1395; Brown & Reavey, 2017), or what can be described as building an "inner logic" (Ernst, 2016, 111) that can account for the disattending to formal rules, etc. For instance, Ryan explained that he disturbed Alba in the no-disturbance zone because "we don't want relatives and others to disturb". Ryan constructed an emergent third way of reasoning between the institutional security logic of no-disturbance and the local safety logic of inter-collegial validation. This construction is not presented as a problem for Ryan, but rather as a taken-for-granted way of doing things:

> Incompatible goals emerge from the organisation and its interaction with its environment. The managing of these conflicts is typically transferred to local operating units (the sharp-end), such as control rooms, patient wards, airline cockpits. The conflicts are negotiated and resolved in the form of countless daily decisions and trade-offs. These are decisions and trade-offs made by individual operators or crews vis-a-vis operational demands: external pressure becomes internalised: the macro becomes micro where global tension between efficiency and safety seeps into local decisions and trade-offs by individual people or groups (…). Some might consider these trade-offs between production and protection to be amoral calculations by managers, (…) but cost and efficiency are taken-for-granted goals in most professions committed to problem-solving under constraints (Dekker & Pruchnicki, 2014, 537–38)

Our integration of cognitive ethnography and phenomenology reveals exactly the cognitive conflict events where "the macro becomes micro" and taken-for-granted issues of cost-benefit trade-offs that nurses take on themselves in such situations. Our proposed method offers a unique opportunity for revealing both the interactional dimension of safety as well as the experiential, that together form risk behaviour and adverse events. Because our method includes concrete experiences, results can easily be communicated back to and understood by nurses, doctors and managers at the ward. Such feedback to the ward is a scheduled part of the concrete research project, and it will involve sharing Ryan's story in Figs. 1 and 2, sharing our interpretation with the ward, and engaging in a dialogue with the staff about how they interpret the event, as well as our analysis of it. While our analysis is limited to a specific hospital institution, it can provide an opportunity for practitioners to reassess their taken-for-granted practices of how time, rules, resources, and intentions should be structured.

5 Conclusion

Cognitive ethnography combined with phenomenological interviews is a method that captures both interactions and experiences in local organisational practices. This is relevant in relation to human errors in healthcare since adverse events are functionally defined as breakdowns in the broader system. Nonetheless, adverse events also remain the product of how organisational members make sense of the institutional setting as well as of their own and each other's behaviour. With cognitive ethnography, we track the cognitive networks that work together towards specific outcomes, and with phenomenological interviews, we elicit subjective descriptions of how organisational members make sense of the same work. The combination of these data-gathering processes allows for an integration of Cognitive Event Analysis and phenomenological interpretation of work sequences, focusing on key moments where agents respond to errors.

We have illustrated the integration of methods in the empirical analysis of a nurse's mundane pill administering, which turns into a complex adverse event as the patient drops a pill to the floor. Our analysis shows that the nurse captures the adverse event successfully without it causing harm to the patient. The successful capture is shaped by a specific layout of environmental affordances that constrain the task, and an intersubjective community at the medical ward that collaboratively makes sense of the task and the environment. However, solving the task in a safe manner requires the nurse and extended cognitive system to break formal safety rules, e.g., by disturbing colleagues in the no-disturbance medicine room. The cognitive system of nurses and patient had to make trade-offs between institutional safety rules and a locally emergent safety and became exposed to increased risk in the process, which points to incompatible goals of formal and local logics in the everyday management of medicine in hospitals. The combination of cognitive and phenomenological methods makes it possible to understand the micro-dynamics of medicine management as well as the intersubjective and experiential dynamics through which the cognitive system negotiates formal and local logics. In conclusion, safe medication administration can itself lead to an increased risk of adverse events, because incompatible safety logics is a source of medical errors in healthcare.

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Data availability Not applicable.

Declarations

All participants have provided their informed consent. The research study has been reviewed by the relevant ethics committee.

Conflicts of interest The authors declare that they have no conflict of interest.

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Article C: The effectiveness of improving healthcare personnel's human factor skills using simulation-based training: A systematic review

(Submitted version)

The effectiveness of improving healthcare personnel's human factor skills using simulation-based training: A systematic review

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Abstract

Background: Simulation-based training used to train healthcare personnel's skills and improve clinical practice has evolved a lot in recent decades. While it is evident that technical skills training is beneficial, the potential of human factor training has not been described to the same extent. Research on human factor training has been limited to marginal and acute care scenarios and often to validate instruments. This systematic review aimed to investigate the effectiveness of simulation-based training in improving in-hospital qualified personnel's human factor skills.

Method: A review protocol outlining the study was registered in PROSPERO. The systematic search was conducted on September 28th, 2021, in eight major scientific databases, using the PRISMA guidelines. Title and abstract screening were assessed by three independent reviewers, full texts were assessed by one reviewer. Content analysis was used to assess the evidence from the included studies.

Results: The search yielded 19,767 studies, of which 72 were included. The included studies were published between 2004 and 2021 and covered research from seven different in-hospital medical specialisms. Studies applied a wide range of assessment tools, which made it challenging to compare the effectiveness of human factor skills training across studies. The content analysis identified evidence for the effectiveness. Four recurring

themes were identified: 1) simulation-based training to improve personnel's human factor skills; 2) assessment of human factor skills; 3) combined teaching methods; and 4) retention and transfer of human factor skills.

Conclusion: Simulation-based training is an effective learning tool to improve qualified personnel's human factor skills. Human factor skills are often considered as innate; they are not and should be recognized as trainable similar to technical skills. Moreover, research on retention and transfer is insufficient. Further research on the retention and transfer of human factor skills from simulation-based training to clinical practice is essential, to gain knowledge of the effect on patient safety.

Keywords: Systematic review, simulation-based training, medical simulation, human factor skills, non-technical skills (NTS), adverse events, teamwork, crisis resource management (CRM), qualified personnel, in-hospital.

Background

Adverse events[1] are common in hospitals all over the world. They cause higher mortality and morbidity, along with more pain and increased healthcare costs (1). Since 2004, the number of reported adverse events in Denmark has been increasing and has stabilised at a relatively high level (2). The Danish Patient Safety Strategy (3) has an organisational approach that addresses adverse events by providing knowledge through guidelines, e-learning, newsletters (4, 5). Providing knowledge implies that adverse events might be avoided through enhanced guidelines and safety procedures. However, several studies find that adverse events often occur in complex situations that differ from the routine, or because of the personnel's human factors, such as biases and personal deficiencies, rather than because of a lack of knowledge (6-9). Human factor skills (HFS), also referred to as non-technical skills (NTS), crisis resource management (CRM) or interpersonal relations (9, 10), comprise cognitive skills such as communication, coordination, decision-making, followership, leadership, situational awareness, teamwork. Patient safety reports indicate

[1] Adverse Events: An event that results in injury or risk of injury during health professional activity. The incident is unintentional and includes known and unknown events and errors that are not due to the patient's illness and that are either harmful or could have been harmful (near-accident).

that adverse events occur in interactions between technology, organisation and HFS, and adverse events are about the understanding of the interactions among humans and other elements of a system, including social and cognitive structures (1, 2, 11). An example is the relocation of healthcare personnel from their everyday work to COVID-19 units (12). This challenged even highly competent personnel and might have caused an increased number of human errors. Personnel had to adapt to unfamiliar procedures - both technical and cognitive, and to new surroundings, complications, colleagues, and workflows. The Danish Patient Safety Database shows a 32% increase in reported adverse events in 2020 (13), with a peak at the beginning of the COVID-19 pandemic.

Research indicates that simulation-based training (SBT) is a safe and effective tool to develop and increase competencies in healthcare (14). However, existing reviews focus on technical skills (TS), self-confidence, self-efficacy and the effectiveness of SBT for unqualified healthcare students (15-18) and develop unqualified healthcare students' HFS (19, 20). SBT has been found to refine qualified healthcare personnel's TS, self-efficacy, and confidence (18, 21). Existing studies of qualified healthcare personnel's HFS focus on developing curricula, specific settings or situations or on tests of new evaluation or rating instruments (22-26). Buljac-Samardzic et al. (27) explored interventions that improved team effectiveness and concluded that SBT enhances teamwork, though interventions studies were limited to certain situations, settings and/or outcomes. As mentioned, HFS are crucial to reducing adverse events (28), but evidence concerning the effectiveness of SBT to refine qualified healthcare personnel's use of HFS is sparse. There is a need for additional knowledge about the effectiveness of developing HFS in qualified personnel with SBT.

Aim

This systematic review aimed to investigate the effectiveness of in-hospital simulation-based training as a learning and teaching method to develop qualified healthcare personnel's human factor skills.

Methods

The AMSTAR 2 -criteria (A MeaSurement Tool to Assess systematic Reviews) were used to prepare the review (29). The review report follows the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (30). Details of the protocol were registered in the International Prospective Register of Systematic Reviews (PROSPERO) (31) (record ID: CRD42021118670).

Search strategy

SPICE (Setting, Perspective/population, Intervention, Comparison, and Evaluation) (32), an alternative to the qualitative conceptualizing model PICO (33), provided a framework for the formulation of questions, keywords, and the search process. The SPICE elements were outlined: Setting = in-hospital healthcare specialisms and units; Population = all authorised qualified clinical personnel, apart from dentists and pharmacologists; Intervention = using SBT to teach HFS; Comparison = SBT compared to classroom teaching or no training; and Evaluation = improvements in the personnel's HFS.

Boolean operators were used to combining keywords and blocks. Furthermore, the databases' unique thesauri, truncation, phrase searches, and proximity searches were included. An experienced information specialist (author TFF) optimised the search. Publications in English, Danish, Norwegian and Swedish were deemed eligible.

The following databases were searched: CINAHL (EBSCO), Cochrane Library, EMBASE™ (OVID), ERIC (EBSCO), MEDLINE® (OVID), PsycINFO (OVID), SCOPUS, and Teacher Reference Centre (EBSCO), September 28th, 2021. Publications were identified in alerts from two key medical simulation journals (Advances in Simulation and Simulation in Healthcare) and reference lists in the included studies (34). Search histories are available in Supplement A.

Study selection and critical appraisal

Covidence (35), a screening and data extraction tool, was used in the study selection process. All study design and publication types were included except reviews, research protocols, and conference abstracts. Authors LA, MLH and ABN individually performed

Inclusion criteria	Exclusion criteria
Studies of qualified healthcare professionals. The population covers post-graduate clinical healthcare personnel, all seniorities and competency levels, for instance midwives, nurses, physicians and respiratory therapists.	Studies were the teams consists of non-qualified healthcare providers. Pre-graduate, students (midwives, nurses, physician etc.), roleplaying staff, dentists or pharmacologist.
Studies of simulation-based training with human patients (artificial, human or combination) focusing on improving HFS, regardless of location (centre or in situ) or group of personnel.	Studies of simulation-based training focusing on technical skills, confidence, self-efficacy, satisfaction, and/or communication with patients or relatives.
Studies of mono- or multidisciplinary teams. A team have four attributes: two or more members with assigned and clear roles, who perform independent task with a common goal.	Studies of team training without simulation-based training, with virtual reality or teams with roleplaying personnel.
Studies investigating the effect of training human factors using simulation-based training.	Studies of test or validation of tools, development of curricula, studies without empirical data, reviews, editorial letters, books.

Table 1: Inclusion and exclusion criteria.

the title and abstract screening using a standardised pre-piloted guide of inclusion and exclusion criteria (Table 1). Conflicts were resolved through dialogue. LA subsequently selected eligible studies for inclusion by full-text reading, and, in cases of doubt, the consensus was achieved by consulting the authors MLH, ABN, LH, and SVS. Each study was scrutinised for validity, reliability, generalisability and replicability of the results, using the Critical Appraisal Skills Programme checklists (CASP) (36), Mixed Methods Appraisal Tool (MMAT) (37), or Critical Appraisal of a Survey (38). The studies were labelled with either a high, medium or low -reliability rating, for use in the analysis of effectiveness.

The analysis process

Content analysis (39, 40) was used as a method to assess the effectiveness. Content analysis is a systematic and objective research method that enables the analysis of qualitative and quantitative content. Stemler's inductive technique was used to analyse the content. From open coding to creating themes, and abstraction (39). The content analysis was framed by the following topics: *characteristics, target population, HFS focus, intervention type and content, type of assessment, outcome, results, and limitations, summaries of intervention effects* for each study. Due to the variation of the included study types, all assessments and methods were analysed and categorised. Every theme was verified and where necessary, revised or split into two.

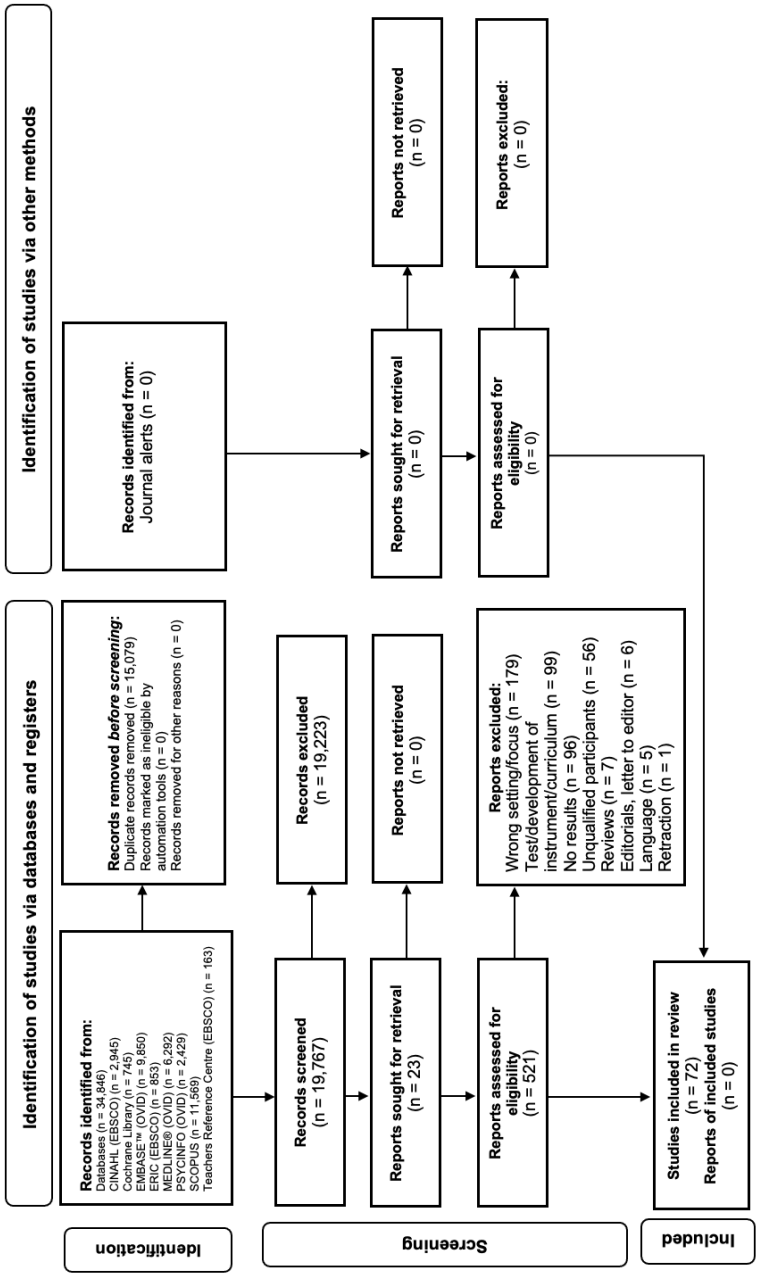

Figure 1: PRISMA flow diagram of the screening and selection process

Results

The initial search identified 34,846 publications, representing 19,767 unique studies, after the removal of duplicates. After title and abstract screening, 521 studies were identified for full-text screening of which 72 were included for data extraction and synthesis. This process is shown in the PRISMA flow diagram (Figure 1).

Result of quality assessment of included studies.

The included studies were of varying quality, as shown in Figure 2. The assessment included factors, such as: unsuitable assessments methods, unclear selection methods, and uneven weighting of HFS and TS, favouring TS in the assessment of effectiveness. No studies were excluded following the quality assessment; however, it was used as an indicator of validity and reliability in relation to the effectiveness of HFS training.

Study characteristics

Included studies were published between 2004 and 2021 and were conducted mostly (n=70) in Western countries. The 72 studies used 51 different assessment methods to measure the outcome of the team training interventions, including: pre-tests, peri-tests and post-tests, (un)blinded ratings, self-assessments, surveys, and interviews. The methods were validated (n=30), non-validated or no information about validation (n=14), and modified versions of validated (n=9) instrument. The studies reported SBT settings such as simulation centres (n=36), in-situ training (n=24), and the use of both centre and in-situ training (n=7). A broad variation was seen in the size and range of the studies (n=7 to 675 participants) and represented SBT within seven different in-hospital medical specialisms: anaesthesiology (n=7), emergency medicine (n=20), intensive care (n=9), internal medicine (n=2), obstetrics (n=12), paediatrics (n=6), and surgery (n=15). A range of teaching methods were used: SBT (n=30); SBT and didactics (n=34); SBT, didactics and workshops (n=6); and SBT and workshops (n=1).

The courses in the included studies were mostly stand-alone (n=51), meaning not part of formal educational (n=18) progress. The participants were either voluntary (n=35), mandatory (n=16), randomly selected participants (n=9) or not stated (n=12). Participants

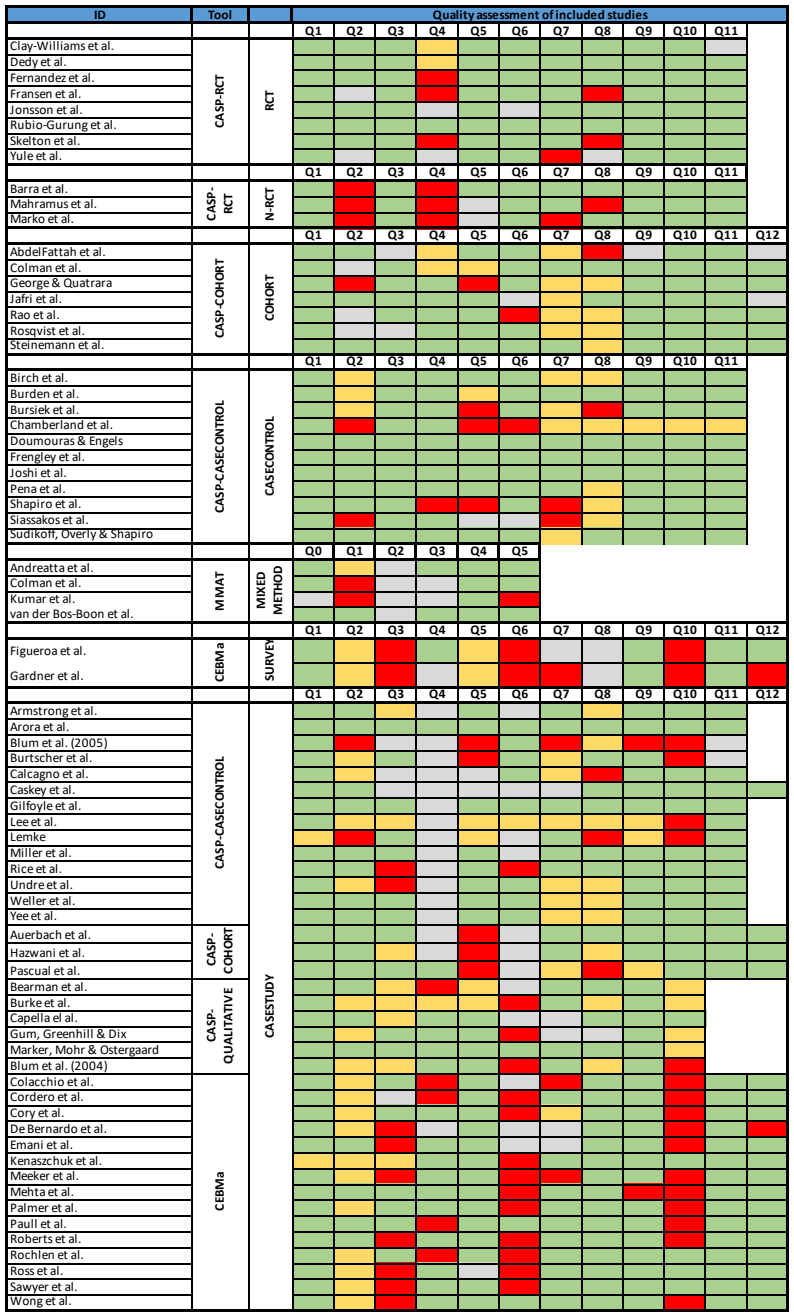

Figure 2: Quality assessment of 72 studies included in a systematic review of The effectiveness of improving healthcare personnel's human factor skills using simulation-based training. Green = Yes, Red = No, Grey = Can't tell, NR = Not relevant

trained one or more of the following HFS: communication, coordination, decision-making, followership, leadership, situational awareness, task management or teamwork.

Team size varied from two to twenty members, typically training in teams of two to five members. Two-thirds of the studies were of multidisciplinary teams (n=47). Midwives, nurses, and physicians were the most common participants, but a total of 13 different disciplines participated. Mono-disciplinary SBT was seen in 20 studies; primarily physicians (n=18) were trained separately from other qualified personnel. An extracted summary of included studies is shown in Table 2, and the full summary is available in Supplement B.

Content analysis

The content analysis identified four recurring themes: 1) SBT improved the personnel's HFS, 2) assessment of HFS, 3) combined teaching methods, and 4) retention and transfer of skills. These themes will be elaborated on below.

SBT improved the personnel's HFS. The vast majority (n=65) of the studies concluded that SBT could develop qualified personnel's use of HFS. In two-thirds of the studies, HFS as the sole focus of the training was seen and were associated with enhanced effectiveness (41-68). These studies were mainly conducted in simulation centres, with smaller teams (n=2-8 members), and the SBT-courses were announced. The majority of the 27 studies (n=22) used validated assessment methods and performed debriefing (n=24) immediately after every SBT scenario. Nevertheless, Emani et al. (54) and Jafri et al. (69) shows a correlation between TS scores and HFS scores, which emphasises that the effect of SBT is evident both when HFS is trained solely and in combination with other competencies. Studies of multi-disciplinary training (n=47) (42, 47, 50, 52-59, 61-64, 66-97) were generally associated with greater effectiveness than mono-disciplinary training, perhaps because multi-disciplinary training better reflect everyday clinical practice.

ID 1 st Author Year of publication Country of study	Studiedesign	Participants (N=) Medical speciality (Mono- /multi disciplinary)	Training type (In situ, Center / (Un)Formal / (Un)Announced)	Intervention (Lecture, Workshop, Simulation (HF /TS))	Improvement Self Assessed Rated Test	Quality (Validity (Hi-Me-Lo), Reliability(Hi-Me-Lo))	Key findings
Clay-Williams 2013 Australia	**RCT**	N=60 Obstetrics (MU)	C / U / A	S (HF) / L - S (HF) / L (HF)	**SA** teamwork P= 0.009 **R** teamwork P = 0.027	Hi/Lo	I = A) No interventions B) Class room C) Simulation D) Class room + simulation No positive changes in teamwork attitudes were found associated with classroom or simulation training. Positive changes were found in knowledge, self-assessed teamwork behaviour and independently observed teamwork behaviour
Dedy 2016 Canada	**RCT**	N=11 Surgery (MO)	C / F / A	L - S (HF)	**SA** TeamSTEPPS P= 0.008 **R** Teamwork P=0.008 **R** NOTSS P=0.012 **R** OSANTS P=0.012	Me/Me	I = Conventional training / NTS simulation Effectiveness of structured training on HFS Participants in the intervention group scored significantly higher on the knowlegde
Fernandez 2020 America	**RCT**	N=60 Emergency Medicine (MO)	C / U / A	L - S (HF)	**R** Ledership P<0.01	Hi/Me	I = No training / Simulation Leadership training Significant difference in post-training leadership behaviors. Leadership training resulted in the transfer of complex skills to the clinical environment and may have an indirect effect on patient care through better team leadership. Strong support for incorporation of more robust team leadership training into trauma education.
Fransen 2012 Netherlands	**RCT**	N=12 Obstetrics (MU)	C+I / U / A+U	S (HF)	**R** Communication P=0.008 **R** Coordination P=0.118 **R** Decision making P=0.01 **R** Situational Awareness P=0.078 **R** Teamwork p=0,014	Hi/Hi	I = Simulation / No training Significant improvement in team performance and a significant increase in the use of new medical technical skills 8 months after obstetric, multiprofessional team training
Jonsson 2021 Sweden	**RCT**	N=75 Intensiv care (MU)	I / U / A	L - S (HF)	R Overall teamwork 0.030 R Leadership P=0.003 R teamwork P=0.508 R task management P=0.030	Hi/Hi	I: online lecture, refelctition session, simulation vs simulation only Education in situation awareness in the intervention group improved leadership, task management and TEAM total. No significant differences were observed in the SAGAT or the ABCDE checklist. shows that a 2-h education in situation awareness improved parts of team performance in an acute care situation. Team leadership and task management improved in the intervention group, which may indicate that the one or several of the components in situation awareness (perception, comprehension and projection) were improved.
Rubio-Gurung 2014 United Kingdom	**RCT**	N=6 Obstetrics (MU)	I / U / U	S (HF - TS)	**R** Task management P=0.01/0.004 **R** Teamwork P<0.001	Hi/Hi	I= Simulation / No training Significantly positive effect of in situ simulation training on multidisciplinary teams in both technical skills and teamwork.
Skelton 2016 Rwanda	**RCT**	N=20 Obstetrics (MU)	? / U / A	L - S (HF)	**R** Overall HFS score P=0.335 **R** Decision making P=0.282 **R** Situational Awareness P=0.465 **R** Task management P=0.865 **R** Team work P=0.195	Me/Me	I = Simulation / No training Improvement in ANTS practice during cesarean delivery after 1 teaching session The ANTS score of the control group was 8, with a statistically significant difference (P = 0.002). Simulation participants showed statistically significant improvement in subcategories and in the overall ANTS score compared with ANTS score before simulation exposure.
Yule 2015 Northern Ireland	**RCT**	N=8 Surgery (MO)	C / F / A	S (HF)	**R** Overall HFS score P=0.04	Hi/Me	I = Simulation + coaching / Simulation Improved residents' HFS in the simulated OR Deliberate practice in the form of non-technical skills coaching can improve critically important intraoperative behaviors and enhance patient safety.
Barra 2018 Italy	**NRCT**	N=15 Anasthesiology (MO)	C / F / A	L - S - W (HF - TS)	**R** Overall HFS score P=0.0007	Hi/Hi	I = Simulation / Cohort control An intensive simulation-based program can be an effective way to acquire and develop basic skills, including HFS Residents significantly improved in all three evaluated areas cognitive, technical and behavioral.

Mahramus 2016 America	**NRCT**	N=73 Emergency Medicine (MU)	C / U / A	L - S (HF)	**R** Teamwork P<0.001 **SA** Teamwork P<0.001	Hi/Me	I = Simulation The simulation-based teamwork training improved measures of percieved teamwork from a multidisciplinary group who routinely respond to code events.
Marko 2019 America	**NRCT**	N=578 Obstetrics (MU)	I / F / A	L - S (HF - TS)	**T** Knowlegde P<0.0001 **R** Teamwork P<0.0001 **R** Teamwork +12 m P<0.0001	Hi/Hi	I = Simulation / 12 month audit No measurements exactly on HFS Multimodal simulation with an interprofessional educational approach improves the knowledge, skills, and safety culture attitudes Severe perineal laceration rates were reduced.
AbdelFattah 2018 America	**Cohort**	N=30 Emergency Medicine (MO)	C / F / A	S (HF)	**R** Overall performance 2013 P<0.1 2014 P<0.1 2015 P<0.1 2015 cohort was statistically significantly better than both the 2013 and 2014	Me/Lo	I = Simulation / Cohort control Trauma-focused simulation improved performance in the clinical setting compared with previous cohorts with no such simulation experience.
Colman 2019 America	**Cohort**	N=128 Intensive Care - Pediatrics (MU)	I / U / A	S (HF)	**R** Communication P=0.005 **R** Decision making P=0.017 **R** Leadership/followership P=0.002 **R** Situational awareness P=0.06 **R** Teamwork P=0.005 **R** Overall teamwork P<0.05 **SA** Overall Teamwork P=0.15	Hi/Hi	I = Simulation training / Teamperfomance in real life Pre- and post-SBT intervention survey data demonstrated an improvement in the perception of teamwork Team performance skills such as communication, role assignment, role clarity, shared mental model, and situational awareness acquired during SBT can be applied to the management of emergency events
George 2018 America	**Cohort**	N=19 Emergency medicine (MU)	I / U / A	S (HF)	**SA** Knowlegde P<0.000 **SA** Teamwork P<0.05	Me/Me	I = Simulation Relatively short SBT is feasible and can increase perception of teamwork Significant improvements on both knowledge test and teamscores demonstrate the effectiveness of the intervention, and retention of the information gained and teamwork skills learned. Participants valued the intervention and recommended to increase the frequency of training.
Rao 2016 America	**Cohort**	N=15 Surgery (MO)	C / F / A	L - S (HF - TS)	**R** Overall Teamwork P=0.010 **R** Communication P=0.002 **R** Decision Making P=0.029 **R** Leadership P=0.004 **R** Situational awareness P= 0.063 **R** Overall technical skills P=0.006	Me/Me	I = Simulation Significant improvement of HFS from before to after team task training, except for the situation awareness category, which showed improvement trending toward significance.
Steinemann 2011 America	**Cohort**	N=137 Emergency medicine (MU)	I / U / A	L - S (HF)	**R** Overall Teamwork P<0.05 **SA** Overall Teamwork P<0.01	Hi/Me	I = Simulation SBT curriculum can improve the teamwork and clinical performance of multidisciplinary trauma teams that include surgical residents. This improvement was evidenced both in simulated and actual trauma settings, and across teams of varying composition.
Birch 2007 United Kingdom	**Case control**	N=36 Obstetrics (MU)	I / N / A	L - S (HF)	**T** Lecture & simulation 98 points **T** Simulation 74 points **T** Lecture 75 points **SA** Overall knowlegde 100% **SA** Communication improved **SA** Teamwork improved	Me / Me	I = A) Theory B) Simulation C)Theory & simulation All teams improved in their performance and knowledge. The teams taught using simulation only (SBT) were the only group to demonstrate sustained improvement in clinical management of the case, confidence, communication skills and knowledge. Did not have enough power to reach statistical significance. A combination of lecture and simulation-based training appears to give the best short-term improvement in team performance.
Burden 2014 America	**Case control**	N=52 Internal medicine (MO)	C / F / A	L or S (HF, TS)	**T** Communication P<0.001 **T** Leadership P<0.001	HI / HI	I = Simulation / +6 month re simulation Resulted in significantly improved team communication and cardiopulmonary arrest management. SBT with deliberate practice of HFS resulted in improved rare event and team management. Residents exposed to simulation communicated and completed HFS more effectively than those taught in a lecture format.

Bursiek 2020 America	**Case control**	N=14 Surgery (MU)	C / U / A	S (HF)	**SA** Overall Teamwork P<0.001 **SA** decision making P<0.05 decrease in falls P=0.02	Me/Lo	I = Simulation /control + 2 and 6 month Only 57% and 50% of the included participated in the 2 and 6 month followup The current intervention seems to have led to significant improvement in nurse and physician perceptions of teamwork and the practice environment.
Chamberland 2018 Canada	**Case control**	N=29 Intensive care (MU)	C / U / A	S (HF - TS)	**R** Communication P<0.001	ME/Me	I = A) Debriefing HFS, B)Debriefing TS Although information sharing improved for all teams, communication quality improved only for experimental teams. Increase in communication effectivness. Increase of effect in both experimental and control, but mostly in experimental group. The retention of the communication decreases in both groups, but mostly in controlgroup.
Doumouras 2017 Canada	**Case control**	N=9 Emergency medicine (MO)	C / F / A	L - S (HF)	**R** Overall Teamwork P=0.001 **R** Communication P=0.01 **R** Coordination P=0.001 **R** Decision making P=0.01 **R** Leadership P=0.02 **R** Situational Awareness P=0.01	HI/Hi	I = Simulation / Historical Beneficial effect and long-term retention after crisis nontechnical skill training.
Frengley 2011 Scotland	**Case control**	N=11 Surgery (MO)	C / U / A	L - S (HF - TS)	**R** Overall Teamwork P<0.02 **R** Communication P<0.04 **R** Coordination P<0.02 **R** Leadership P<0.02	Hi/Hi	I = Simulation / Feedback SBT seems to be an effective teaching strategy The participants feedback was that the course was relevant, increased confidence of emergency events
Joshi 2018 America	**Case control**	N=46 Emergency medicine (MO)	C / U / A	S (HF)	**R** Situational Awareness P<0.05 **R** Task management P<0.01 **R** Overall Teamwork P<0.05	Me/Me	I = Simulation stabel team / Simulation dynamic team Simulation is an effective method for enhancing team competencies. Teamwork can improve across simulation scenarios regardless of team membership, whereas clinical effectiveness requires team stability to develop and improve. Less changes in improvements teams
Pena 2015 Australia	**Case control**	N=40 Surgery (MO)	I / U / A	L - S - W (HF)	**R** Overall Teamwork P<0.001 **R** Communication P<0.001 **R** Decision making P<0.001 **R** Leadership P<0.001 **R** Situational awareness P=0.001	Hi/Me	I = Simulation / Simulation + HFS workshop HFS training is feasible and can impact positively participants' nontechnical performance in a simulated environment. The addition of a 1-day didactic workshop does not seem to provide additional benefit over simulation-based training as a sole strategy for nontechnical skills training.
Shapiro 2004 America	**Case control**	N=16 Emergency medicine (MU)	C+I / U / A+U	L - S (HF)	**R** Coordination P=0.12 **R** Teamwork P=0.07	Lo/Me	I = Simulation / No simulation There were no significant differences between experimental and comparison groups at baseline SBT appears to be a promising method for enhancing didactic teamwork training Unclear how much simulator based training must augment didactic teamwork training for clinically meaningful differences to become apparent.
Siassakos 2009 United Kingdom	**Case control**	N=24 Obstetrics (MU)	C+I / U / A	S - W (HF)	**R** Communication P=0.002	Lo/Me	I = HFS lecture + simulation / Simulation Teams that received additional teamwork training used more directed commands after training 'on-site' clinical drills can improve team communication in simulated emergencies, and additional teamwork training might improve this further,
Sudikoff 2009 America	**Case control**	N=16 Anasthesiology (MO)	C / F / A	L - S (HF - TS)	**R** Communication P=0.36 **R** Coordination P=0.0004 **R** Decision making P<0.0001 **R** Leadership P=0.0008 **R** Task management P=0.011 **R** Teamwork P=0.0088	Me/Hi	I = Simulation + lecture + workshops / simulation Supports SBT for improving performance and teamwork skills. Showed significant relationship between the intervention and the performance. Behaviorally Anchored Rating Scale improved at each session though statistically unrelated to the intervention.
Andreatta 2011 America	**Mixed method**	N=228 Pediatrics (MO)	I / U / U	S (HF - TS)	**R** Survival rates P=0.000 **Audit** 50 % increased survival rates	Me/Hi	I = Simulation Survival rates increased to approximately 50% correlating with the increased number of mock codes. Results are significantly above the average national pediatric CPA survival rates and held steady for 3 consecutive years, demonstrating the stability of the program's outcomes. SBT code program may significantly benefit pediatric patient CPA outcomes—applied clinical outcomes—not simply learner perceived value, increased confidence, or simulation-based outcomes.

Colman 2019 America	**Mixed method**	N=35 Intensive Care - Pediatrics (MU)	C+I / U / A	S (HF)	**R** Overall Teamwork P=0.005 **R** Communication P=0.005 **R** Coordination P=0.007 **R** Decision making P=0.017 **R** Leadership P=0.002 **R** Situational Awareness P=0.06	Hi/Hi	I = Team performance in clinic after simulation Improvement in the perception of teamwork, most notable in the area of shared mental model and situational awareness following SBT Teamwork behaviors and skills acquired during SBT can translate into improved bedside performance Significant improvement in 12 out of 15 composite teamwork skills during real emergency events
Kumar 2018 Australia	**Mixed method**	N=237 Obstetrics (MU)	I / F / A	S (HF - TS)	**SA** Communication 37% **SA** Leadership 31% **SA** Task management 33% **SA** Teamwork 20%	Lo/Lo	I = Simulation Change in the management of postpartum haemorrhage by early recognition and intervention. Participants reported a positive learning experience and increase in confidence Improvement of both clinical and non-technical skills highlighting principles of teamwork, communication, leadership and prioritisation in an emergency situation. No significant change was noted in clinical outcomes over a 2-year period
van den Bos-Boon 2021 Netherlands	**Mixed method**	N=71 Intensive Care - Pediatrics (MO)	C / U / A	L - S (HF - TS)	**SA** Communication improved SA Teamwork improved **R** Communication improved **R** Teamwork improved **R** Task management improved	Me/Me	I=E-learning, cecture, simulation This study shows encouraging improvement ofnurses' resuscitation and teamwork skills in a simulation setting following a proficiency check for resuscitation. We may not automatically assume that this effect can be translated to the real-life setting, and this should be explored in future research.
Figueroa 2013 America	**Survey**	N=37 Intensive care - Pediatrics (MU)	C / U / A	S (HF - TS)	**SA** Communication P=<0.05 **SA** Leadership P=<0.05 **SA** Task management P=<0.05 **SA** Teamwork P0<0.05	Hi/Hi	I = Lecures + simulation Confidence and skill in the roles of team leader, advanced airway management, and cardioversion/defibrillation were increased significantly. A significant increase also was observed in the use of Team STEPPS concepts.
Gardner 2008 America	**Survey**	N=58 Obstetrics (MU)	C / U / A	S (HF - TS)	**SA** Communication 92,5% **SA** Leadership 85% **SA** Teamwork 90%	Hi/Lo High number of wiithdrawals	I = Simulation Reported improved teamwork and communication in managing a critical obstetric event in the interval since taking the course. SBT HFS training can serve as a strategy for mitigating adverse perinatal events
Arora 2015 United Kingdom	**Case study**	N=185 Surgery (MO)	I / F / A	S (HF - TS)	**R** Communication P=? **R** Decision making P<0.001 **R** Leadership P=? A significant improvement in the teams' communication, coordination, cooperation, leadership, situation awareness, and decision-making skills	Hi/Hi	I = Simulation Evidence for the efficacy ofward-based team training using simulation. Focus on the Technical outcome, HFS outcome described in 2 sentences
Armstrong 2020 New Zealand	**Case study**	N=15 Emergency Medicine (MU)	C+I / U / A	L - S (HF - TS)	**R** Coordination P=0.006 **R** Communication P=0.1064 **R** Decision making P<0.0001 **R** Leadership P=0.0031 **R** Situational Awareness P=0.0008	Hi/Me	I=Lecture, simulation Simulation is an effective training tool for improving teamwork and senior nurse leadership skills in the novel setting of nurse and doctor shared leadership during CPR. Wider benefits of nurse empowerment and interdisciplinary training is ripe for further qualitative review.
Auerbach 2014 America	**Case study**	N=269 Emergency Medicine - Pediatrics (MU)	I / U / U	S (HF - TS)	**R** Overall Teamwork P=0.002 **R** Task Management P=0.002 Statistically significant trends over time in (a) overall performance, (b) the teamwork component	HI/Hi	I = Unannonced in situ simulation Improved validated trauma simulation assessment scores for overall performance, teamwork, and intubation Most valuable aspect of this simulation: Debriefing, High-acuity trauma training, Teamwork and communication training, Review of policies. In situ trauma simulation is a sustainable and effective method to reinforce teamwork and trauma skills
Bearman 2012 Australia	**Case study**	N=11 Surgery (MO)	C / U / A	L - S - W (HF - TS)	**SA** Highly useful, better comunication, teamwork **SA** 90 % would recommend **SA** 82 % better HFS + TS	Me/Me	I = Lectures, workshops and HF simulation SBT is feasible to teach competencies in communication, teamwork, leadership, and the encompassing professionalism to surgical trainees
Blum 2004 America	**Case study**	N=55 Anasthesiology (MO)	C / U / A	L - S (HF)	**SA** Overall HFS I = 4.80 1Y = 4.82 (1-5 scale) **SA** Communication P<0.035	Me/Me	I = Lecture, simulation, focus on CRM Improvement in their CRM non-technical skills. Indirect evidence supporting the contention that this type of training should be more widely promoted, although more definitive measures of improved outcomes are needed

Blum 2005 America	**Case study**	N=38 Anasthesiology (MU)	C / U / A	L - S (HF)	**SA** Communication P<0.05 **R** Communication (Probe placing) 56 % succesful, 33 % overheard P>0.2	Lo/Mo	I = Simulation + lecture + simulation There was no statistical difference in "group sharing" from beginning to end of training, despite trainees' survey responses that the course would be useful for their education and practice.
Burke 2017 America	**Case study**	N=55 Emergency Medicin - Pediatrics (MU)	I / U / A	S (HF)	**SA** Communication **SA** Coordination **SA** Leadership **SA** Teamwork	Me/Lo	I = Simulation / Focus group interview Valued the practice they received during trauma simulations and supported the continuation ofthe simulations to improve trauma activation teamwork and communication
Burtscher 2011 Switzerland	**Case study**	N=30 Anasthesiology (MU)	I / U / A	S (HF)	**R** Communication P=0.86 **R** Task management P=0.45 Participants spent an average of 35.22% of their time on coordination activities	Hi/Hi	I = Simulation Adaptation of coordination activities is related to improved team performance in healthcare
Calcagno 2018 America	**Case study**	N=12 Anasthesiology (MO)	? / U / A	S (HF - TS)	**R** Communication P=0.38 **R** Decision-making P=0.91 **R** Leadership P=0.29 **R** Situational awareness P=0.08	Me/Lo	I = Simulation HFS Multidisciplinary simulation transcend the individual experience by allowing trainees to develop algorithms for crisis management and to improve on aspects of teamwork, leadership, and communication skills that can be applied throughout their careers Multidisciplinary learning has real-world practicality, enhances communication, and is linked to measurable improvements.
Capella 2010 America	**Case study**	N=73 Emergency medicine (MU)	I / U / A	L - S (HF)	**R** Communication P=0.001 **R** Leadership P=0.003 **R** Situational awareness P=0.009 **R** Teamwork P=<0.001	Hi/Me	I = Simulation Significant improvement in all teamwork domain ratings and overall ratings from pretraining to posttraining
Caskey 2017 America	**Case study**	N=9 Surgery (MO)	? / F / A	L - S - W (HF - TS)	**SA** Communication P<0.01 **SA** Coordination P<0.01 **R** Overall Teamwork P<0.0001 **R** Communication P<0.0001 **R** Decision-making P<0.0001 **R** Leadership P<0.0001 **R** Situational awareness P<0.0001	Hi/Hi	I = HFS + TS lectures, workshops and HF simulation SBT HFS training for laparoscopic cholecystectomy (that was separate from technical skills training) led to a sustained increase in residents' HFS
Colacchio 2012 America	**Case study**	N=154 Intensive Care - Pediatrics (MU)	C / U / A	L - S (HF)	**SA** Improvements in teamwork, leadership, situational awareness and communication on 0.62-0.88 points (5-point Likert scale)	Me/Me	I = HFS lecture + simulation Although participants had a positive perception of their teamwork skills pre-training, the majority still found the course useful and all sessions resulted in recommendations for improved teamwork made by participants
Cordero 2013 America	**Case study**	N=26 Pediatrics (MO)	C / U / A	L - S (HF - TS)	**R** Overall Teamwork P=0.37 **R** Communication P=0.25 **R** Leadership P>0.99 **R** Task management P=0.25	Lo/Lo	I = Simulation Significant improvement in team communication was noted. Residents' improvements in selfconfidence did not reflect gains in actual performance. The HFS simulation offers opportunities for NR and team skills training and assessment.
Cory 2020 America	**Case study**	N=72 Intensive Care - Pediatrics (MU)	I / U / A	S (HF)	**SA** Communication P<0.05 **SA** Coordination P>0.05 **SA** Leadership P<0.05	Me/Lo	I = Simulation Multidisciplinary simulation-based team training in the pediatric cardiac intensive care unit improves knowledge of HFS principles in addition to improved perception of effective teamwork. Subgroup analysis demonstrated that the participants with less than five years of experience had a significant increase in the correct response rate on how to use closed-loop communication
De Bernardo 2016 Italy	**Case study**	N=23 Pediatrics (MU)	C / F + U / A	L - S - W (HF - TS)	**SA + R** Improvements i HFS from 34 to 42 points (max point 45)	Me/Lo	I = Lecture - simulation / +2 month Limited impact on technical and non-technical skills of participants working in low level hospitals. Training programs should be tailored to the participants' professional background and to the more relevant sessions. Technical and nontechnical scores were significantly correlated
Emani 2018 America	Case study	N=23 Intensive Care - Pediatrics (MU)	I / U / A	L - S (HF)	**R** Communication P=0.018 **R** Coordination P=0.026 **SA** Teamwork P=0.033	Me/Me	I = Lecture + Simulation Simulation training implemented in low-resource environments can result in significant improvements in communication Simulation fosters a culture of open communication and idea acceptance

Gilfoyle 2017 Canada	**Case study**	N=300 Pediatrics (MU)	C / U / A	L - S (HF - TS)	**R** Overall Teamwork P<0.0001 **R** Communication P<0.0001 **R** Decision making P<0.0001 **R** Situational awareness P<0.0001	HI/Hi	I = Lecture, simulation A positive correlation between clinical and teamwork performance suggests that effective teamwork improves clinical performance of resuscitation teams
Gum 2010 Australia	**Case study**	N=17 Obstetrics (MU)	? / ? / ?	L - S (HF - TS)	**SA** Increase in personal role awareness, which included role definition, scope of practice and communicating roles.	Me/Lo	I = Simulation workshop / Interview + postworkshop Significance of interprofessional training, particularly through simulation learning in a team where rural clinicians are able to learn more about each other and gain role clarity, leadership skills and mutuality in a safe environment. It is argued that no 'single' teamwork training course can alter attitudes, and change in work culture can only be achieved through repetitive training
Hazwani 2020 Saudi Arabia	**Case study**	N=492 Pediatrics (MU)	I / F / U	S (HF - TS)	**R** Overall Teamwork P=0.230 **R** Leadership P<0.0001 Improvements in communication	Me/Me	I = Simulation In situ code simulation is a helpful way to enhance team performance and improve the quality of cardiac resuscitation.
Jafri 2021 America	**Case study**	N=162 Emergency Medicine - Pediatrics (MU)	C / U / A	L - S (HF - TS)	**R** Overall Task management P<0.001 **R** Overall Teamwork P<0.001 **R** Communication improved **R** Decision making improved **R** Situational Awareness improved	Hi/Me	I: Simulation, group discussions A interprofessional program in a community hospital site demonstrating that teaching CRM skills can improve simulated team performance in a diverse experienced cohort. Also moderate positive correlation between CTS and CPT among all 48 cases, pre and post combined.
Kenaszchuk 2011 Canada	**Case study**	N=154 Internal Medicine (MU)	C / U / A	L - S (HF)	**SA + R** Attitudes toward teamwork did not exhibit linear growth **SA + R** Attitudes toward shared leadership had significant differences.	Hi/lo	I = Lecture, simulation SBT shared leadership may provide the most leverage to improve interprofessional care. Attitudes toward healthcare teamwork likely did not exhibit linear growth in the six-week follow-up. These results may undermine confidence in the ability of simulation activities to substantially improve interprofessional attitudes in the long run.
Lee 2021 America	**Case study**	N=? Emergency medicine - Pediatrics (MU)	I / U / A	S (HF - TS)	**SA** Communication Improved **SA** Teamwork improved	Lo/Lo	I: Simulation Teamwork and communication, as measured by the TeamSTEPPS Team Performance Observation Tool, improved from the baseline to 12-month assessments for both scenarios, but scores did not change over the 12-month period.
Lemke 2020 America	**Case study**	N=81 Emergency medicine - Pediatrics (MO)	C / F / A	L - S (HF - TS)	**SA** Communcation improved **SA** Teamwork improved	Lo/Lo	I: Simulation, rapid cycle deliberate practice, coaching This technique was well received and provided positive feedback on the sessions. In particular, when asked if the course "improved my teamwork and leadership skills" they agreed with a mean score of 4.9 out of 5.
Marker 2019 Denmark	**Case study**	N=19 Emergency Medicin (MO)	C / F / A	L - S - W (HF)	**SA** Structured communication **SA** Understanding the role of other team members **SA** Role as leader **SA** Plan and prepare **SA** Decision making **SA** Use of HFS in clinical practice was found to be helpful in meeting the medical expertise challenges.	Me/Me	I = Lecture, workshops, simulation SBT increasing their preparedness for clinical practice and handling the critically ill patient Concern was expressed related to staff willingness and preparedness in using these tools. Experienced an ability to transfer the use of algorithms and non-technical skills trained in the simulated environment to the clinical environment. The application of these skills was more difficult if these skills were unfamiliar to the surrounding clinical staff.
Meeker 2018 America	**Case study**	N=36 Obstetric (MU)	C + I / U / A	S (HF - TS)	**SA** Communication P=0.03 **SA** Teamwork P=0.04 **SA** Follow-up (+3M) 90.9% percieved improved teamwork and communication	Me/Me	I = Simulation Participants experienced promoted enhanced communication and teamwork
Mehta 2013 United Kingdom	**Case study**	N=78 Surgery (MU)	I / U / A	S (HF - TS)	**SA + R** Enhanced clinical knowledge **SA + R** Address non-technical skills	Hi/Hi	I = Simulation Improvement in clinical knowledge, teamwork, leadership and non-technical skills, as well as the mutual understanding and respect between related medical and non-medical team members Emphatically demonstrate the universal success of this multi-disciplinary training method for all team members, regardless of hierarchical position or background.

Miller 2012 America	**Case study**	N=80 Emergency Medicine (MU)	I / U / ?	L - S (HF)	**Simulation** **R** Communication P = 0.003 **R** Coordination P=0.037 **R** Decision making P=0.015 **R** Leadership/Followership P=0.018 **R** Situational Awareness P=0.035 **R** Teamwork P=0.020 **Transfer** **R** Communication P=0.003 **R** Coordination P=0.069 **R** Decision making P=0.047 **R** Leadership/Followership P=0.050 **R** Situational Awareness P=0.066 **R** Teamwork P=0.059	Hi/Hi	I = Lecture, simulation / Simulation Teamwork and communication in the clinical setting were improved, this effect was not sustained after SBT were stopped. Only overall communication appeared significantly different Comparing the didactic phase to baseline, only closed-loop communication was significantly different. Comparing the ISTS phase to baseline, nearly all of the communication component measures were significantly improved over baseline Transfer: yes, but not significant
Palmer 2019 America	**Case study**	N=23 Obstetrics (MO)	C / U / A	S (HF)	**SA** Communication P=0.013 **SA** Leadership P=0.085 **SA** Situational Awareness P=0.008 **SA** Teamwork P=0.001	Me/Me	I = Simulation Supports the use of SBT to enhance team-based training, performance, and communication Participants identified prebriefing and debriefing as a valuable experience
Pascual 2011 America	**Case study**	N=12 Intensive care (MU)	C / F / A	S (HF)	**R** Decision making P<0.01 **R** Situational Awareness P<0.05 **R** Teamwork P<0.01	Lo/Lo	I = Simulation, debriefing Leadership/ interpersonal skills scores improved significantly. SBT improves leadership, teamwork, and self-confidence skills in managing medical emergencies.
Paull 2013 America	**Case study**	N=325 Surgery (MU)	C + I / F / A	L - S (HF)	**R** Communication 16% **R** Decision making 18% **R** Leadership/Followership 18% **R** Situational Awareness 12% **R** Teamwork 19%	HI/Hi	I = Simulation Teamwork and communication scores improved 14 of the 15 observed skills showed significant improvement that ranged from 15% to 23%. SBT improves teamwork and communication skills among interprofessional staff caring for postoperative patients.
Rice 2016 America	**Case study**	N=7 Emergency medicine (MO)	C / U / A	L - S (HF)	**Observed** **R** Overall Communication P=0.001 **R** Overall Situational Awareness P=0.000 **R** Overall Teamwork P=0.000 **Attitude** **SA** Overall Communication P=0.001 **SA** Overall Teamwork P=0.041 **Perception** **SA** Overall Communication P=0.009 **SA** Overall Teamwork P=0.021	Hi/Hi	I = Simulation, lecture (between scenarios) Improved teamwork attitudes, perceptions, and performance. Team communication demonstrated significant improvement Team training increases communication and decreases patient errors. Combining simulation training with team training improves the function of teams.
Roberts 2013 America	**Case study**	N=45 Surgery (MU)	I / U / A	L - S (HF)	**R** Communication P=0.015 **R** Cooperation P=0.01 **R** Decision making P=NS **R** Leadership P=NS **R** Situational Awareness P=0.05	Hi/Me	I = Lecture, simulation Brief training exercises can change teamwork and communication behaviors on ad hoc trauma teams. Transfer after 3 W - lost retention
Rochlen 2019 America	**Case study**	N=27 Surgery (MU)	I / U / A	S (HF)	**SA + R** Team nontechnical skills improved from the first simulation to the second simulation during the intervention.	Me/Me	I = Simulation Improved team HFS scores when assessed following intervention. Participants found the intervention to be effective and beneficial to their learning. Transfer self-aassessed
Rosqvist 2021 Finland	**Case study**	N=225 Emergency medicine (MU)	I / F / ?	S (HF)	**R** Overall HF P<0.001	Me/Me	I= In situ simulation the non- technical skills of the participating trauma teams improved statistically significantly after the simulation training course when evaluated using the T- NOTECHS instrument.

Sawyer 2013 France	**Case study**	N=42 Pediatrics (MU)	? / U / A	L - S (HF)	**Observed** **R** Communication P<0.001 **R** Leadership P<0.001 **R** Situational Awareness P<0.001 **R** Teamwork P<0.001 **Attitude** **SA** Overall Communication P<0.001 **SA** Overall Teamwork P<0.001	Hi/Hi	I = Lecture, simulation Significant improvements in teamwork skills - team structure, leadership, situation monitoring, mutual support and communication Challenges by nurses to a scripted medication order error doubled from 38% - 77%, a significant improvement
Undre 2007 United Kingdom	**Case study**	N=80 Surgery (MU)	C / U / A	S (HF - TS)	**R** Communication P<0.001 **R** Decision Making P>0.05 **R** Leadership P<0.05 **R** Situational Awareness P<0.001 **R** Teamwork P<0.001	Me/Me	I = Simulation Multidisciplinary simulation-based team training is feasible and well received by surgical teams. HFS can be assessed alongside technical skills, and differences in performance indicate where there is a need for further training.
Weller 2016 NewZealand	**Case study**	N=213 Surgery (MU)	C / U / A	S (HF)	**R** Communication P=0.001 **R** Situational Awareness P=0.01 **R** Teamwork P=0.001	Me/Me	I = Observation, simulation, observation Improvement in scores for teamwork and communication in general surgical OR. Scores for teamwork and communication in the clinical environment improved by more than 20%
Wong 2016 America	**Case study**	N=72 Emergency medicine (MU)	C / U / A	L - S (HF)	**SA** Communication P=0.107 **SA** Leadership P=0.029 **SA** Situational Awareness P=0.014 **SA** Teamwork P<0.0001 **Patient safety measure** **R** Communication P=0.648 **R** Teamwork P=0.035	Hi /Hi	I = Lecture, simulation Improving participant attitudes toward teamwork and components of patient safety culture related to teamwork and communication (transistion P=0.024, organisational learning P=0.057)
Yee 2015 Canada	**Case study**	N=20 Anaesthesiology (MO)	C / U / A	L - S (HF)	**R** Coordination P<0.05 **R** Decision Making P<0.05 **R** Situational Awareness P<0.05 **R** Task management P<0.05 **R** Teamwork P<0.05	Me/Me	I = Lecture, simulation A single exposure to anesthesia crises using a high-fidelity patient simulator can improve the nontechnical skills of anesthesia residents. Simulation based education is beneficial and can significantly improve the nontechnical skills ability of residents Impression from both teachers and participants is that simulation-based education is very useful.

Table 2: Extracted summary of studies included in a systematic review of the effectiveness of improving healthcare personnel's human factor skills using simulation-based training. The full summary of all included studies is available in Supplement B.

Three studies showed potential effect (66, 88, 94), concluding that SBT is a promising tool to train HFS, but that more applicable assessment methods are needed. Only two studies did not show effect (80, 93); they mention positive selection bias because high numbers of participants withdrew, along with methodological problems and lack of assessment methods as possible causes of the non-effect result.

The trainees were mainly personnel from acute or high-intensity medical departments, and nearly all the trained situations involved acute life and death situations. Only four studies (63, 69, 88, 95) trained HFS in day-to-day work, such as reducing falls, ethical issues, delirium, the busy ward, and caring for older patients and relatives. A paediatric focus was found in 25 SBT studies, in anaesthesiology, intensive care, and obstetrics (50, 54-56, 67, 69-72, 75, 76, 78, 81, 83, 85, 86, 93, 97-104). In total, 3,251 of the participants were trained in acute paediatric scenarios. HFS during resuscitation (n=20) was the second most trained situation (43, 46, 47, 53, 55-57, 60, 67, 71, 73, 82, 84-86, 96, 99-103, 105, 106), involving 1,887 personnel. This illustrates that acute and high-intensity situations are the main focus of SBT. Common to these training situations are available algorithms and checklists of the TS (e.g., acute caesarean, cardiopulmonary resuscitation), which facilitate a form of corrective actions. However, complying with checklists and training algorithms does not cover the dynamics in HFS only the tasks in the procedure which could be the reason why the focus on TS overtakes the HFS in some of the studies, for instance in Burden et al. and Siassakos et al. (94, 107).

Assessment of HFS. The studies lack an adequate description of how HFS refinements should be assessed. Existing HFS assessment tools are insufficient, which was emphasised in 28 studies (43, 49, 52, 55, 59, 60, 63, 66, 70, 73, 75, 76, 79, 80, 82, 84, 90, 91, 93, 94, 98, 102, 108-112). Assessment methods (n=51) spanned quantitative, qualitative and mixed methods, validated and non-validated methods, rating of behavioural markers, rating via checklists, interviews, self-assessments, passing probes of information, measuring time, and evaluation of reported experiences. Even though the studies used different assessment methods, they concurred in the conclusion that HFS enhanced among the participants. In 68 studies, HFS was considered to have improved and a significant development in HFS as a result of SBT was shown in 33 studies (41-43, 45-50, 53, 54, 57,

59, 60, 67-72, 74, 75, 78, 82, 85, 95, 96, 99, 102, 103, 105, 111, 113). In conclusion, SBT can refine HFS.

The primary challenge in assessing HFS was a lack of definitions for HFS and insufficient coverage of many different HFS. HFS were undefined or broadly described in several studies, or the assessment was unfit for HFS, such as measuring the time from the outset of a procedure to a certain action or treatment (45, 55, 56, 78, 84). HFS training associated with specific behaviour markers were the most successful assessment (43, 48, 53, 60, 67, 68, 74, 96, 97, 105, 111). The methods used were generally inspired by five tools: crisis resource management (114, 115); Kirkpatrick Model: Four Levels of Learning Evaluation (116); Mayo High-Performance Teamwork Scale (117); Ottawa Global Rating Scale (118); and TeamSTEPPS® (119).

The rating of markers was either blinded or unblinded by internal or external faculty, or assessed by the participants themselves. Self-assessments were used in 31 studies. Self-assessment were used in combination with other methods in 18 studies (41, 47, 51, 54, 60, 62, 63, 67, 73, 76, 80, 83, 88, 90, 92, 93, 103, 113), whereas 13 studies used self-assessment as the only method (77-79, 82, 87, 89, 95, 97, 100, 102, 104, 106, 109). There are inherent challenges in using rating and self-assessments because assessors must be congruent and unbiased, and participants tend to overrate their performance and therefore the method has been proven unreliable (120, 121). Some studies (n=21) used video recording and blinded assessors (41, 42, 48, 52, 54, 55, 58, 61, 65, 66, 69, 71, 84, 86, 93, 94, 98, 101, 103, 108, 111), which increased the validity of the ratings; because the assessors' could rewind the video and review the situation multiple times. Other studies rated participants in real-time, which challenged the assessors' ability to simultaneously watch, listen and rate (43-45, 47, 51, 53, 57-60, 62, 63, 67, 68, 70, 72-74, 76, 80, 88, 91, 96, 102, 105, 107, 112).

The most frequently trained HFS were communication, leadership, and teamwork. The specification of the trained HFS were described in various ways. Eleven studies (48, 56, 64, 66, 93, 95, 96, 98, 105, 111, 112) described HFS with behaviour markers, attitudes or as a definition of the chosen HFS, while others (n=15) only mentioned the HFS in broad indefinite terms such as communication or teamwork (43, 51, 52, 58, 68, 71, 74, 80, 83,

84, 97, 101, 103, 104, 109). Communication and teamwork were the two most trained HFS.

Communication and teamwork are both broad terms. In this context, communication includes, for instance, closed-loop communication (122), delegation, coordination and "speak up". Teamwork covers information-sharing, re-evaluation, support of the team, and allocation of roles and competencies (123, 124). The studies that described HFS using either behaviour markers or attitudes succeeded to a greater extent in assessing HFS and developments than those that described HFS in broad, indefinite terms. It is difficult to assess and report the effect of training when the focus is on broad terms such as communication and teamwork, without a definition or level of detail. It is not possible to distinguish between teamwork/communication and cognition. Communication and teamwork are not isolated and unequivocal tasks; they depend on and influence each other. The purpose of outlining and dividing the tasks into behaviour markers is to simplify a complex clinical situation, i.e. to highlight easily recognisable behaviour for the participants, which makes it easier to acquire and develop skills (115, 123). While communication and teamwork are immediately recognisable and useful interpretations for training personnel, to assessors they are high-level concepts difficult to rate. However, the studies that reflected on the use of high-level concepts and worked to specify these in behaviour markers achieved greater internal validity along with assessed validity (41, 42, 44, 46-49, 56, 60-62, 64-67, 69, 70, 72, 73, 91-93, 95, 96, 98, 102, 105, 111, 113).

Combined teaching methods. Significant effects on HFS were observed in 32 of the studies that combined SBT with didactics and/or workshops, compared to 12 that just trained SBT. The effect on qualified personnel's use of HFS was evident, regardless of whether SBT was combined with didactics and/or workshops, or if they were training HFS on their own or in combination with TS. HFS training was combined with TS training in 30 of the studies, of which 19 showed a significant effect on one or more HFS, equalling 48 of all the included studies. Thus, it appears that the studies in which HFS training was separate to TS training resulted in the greatest improvements in the personnel's use of HFS.

The studies that combined HFS and TS training tended to have a greater focus on TS. For instance, Burden et al and Siassakos et al. covered the results of HFS training with

only a few sentences (94, 107), and Hazwani et al. asserted that a refined time to first medicine infusion in cardiopulmonary resuscitation training was because of an enhancement in teamwork (56).

Retention and transfer of skills. Retention or transfer of HFS was explored in 21 of the studies. The retention of HFS were measured from participants' knowledge, self-assessment, audits and/or patient outcome. Transfer of enhanced HFS are identified in 20 studies, but in two of these (74, 99) the authors identify transfer due to developed TS. The researchers argue that improved TS and time decrease in the accomplishment of the procedure are due to an increase of HFS skills. Roberts et al. finds transfer of HFS, but with low retention over time (61). The transfer of HFS was measured as a decrease in adverse events and improved patient outcomes in six studies (43, 53, 74, 90, 92, 99).

Discussion

This review revealed major support for training HFS in the clinical setting using SBT; however, there is a lack of agreement as to which tools are best to assess HFS. All assessment methods in SBT should be supported by valid evidence. Several instruments are designed to evaluate the effect of HFS skills through SBT, but this review shows that the existing assessment methods are not solid enough to establish consensus on the way HFS are assessed. Although tools exist to assess HFS, methods to study communication and other team-related processes are far from being standardised, which makes comparison challenging. Cognition is a mental process within the personnel in all situations, including learning. It is important to add behaviour and attitude markers to the teaching/learning situation if the goal is to enhance the personnel's HFS. Nevertheless, 43% of the studies show significant effectiveness in refining HFS using SBT, and 92% of the studies show some developments. Regardless of multiple assessment methods, this review shows a significant or improved effect of HFS using SBT, and the outcome was relatively homogeneous – HFS improves using SBT. This adds to the reliability of the review. The differences among the methods in the included studies are, therefore, not a weakness of the research, but rather a strength for the results.

The review also demonstrates that studies in which HFS was trained alone had a greater effect than studies that focused on both HFS and TS. However, although the increase of HFS was lower in combined TS and HFS training, HFS was still enhanced in most studies. In SBT research, HFS are often relegated to the role of an add-on to develop procedures, algorithms, and associated TS in specific settings. This may be for several reasons. Because everyday clinical situations involve both HFS and TS, they are trained together, or because it is easier to measure technical outcomes. HFS often play a minor role in the conclusions drawn. In this way, TS "steal" the focus, and the focus is on solving the medical problem at hand (e.g. bleeding or anaphylaxis), rather than improving HFS, which generally are the cause of most adverse events (28). HFS are unfortunately often understood as innate skills and not skills that can be trained and refined. HFS are not innate, they are generic and important in reducing adverse events within healthcare and needs to be qualified and trained just as seriously as technical skills and clinical procedures.

It is important to understand learning as holistically, integration of the individual, brain, body, and surroundings (125). All levels of learning involve both physical and cognitive stimulations, and if the content is too vast the learning decreases. Focusing exclusively on HFS in SBT seems to lead to a deeper awareness of human factors effect on patient safety among personnel and consequently deeper learning. The results show that SBT for HFS alone, in combination with didactics and/or workshops may lead to the greatest improvement in personnel's HFS. This is substantiated by Maturana's theory of suitable disturbances (126, 127), which deals with how disturbances should be moderated. If a disturbance is too big, the learners might lose attention and if the disturbances are too small, the learners might not even notice. Accordingly, if TS and HFS are trained together, the educational disturbance to participants' behaviour might be too huge for participants to engage with. However, the link to clinical practice is still underdeveloped.

Conclusion

This systematic review demonstrates that SBT is an effective learning tool to improve HFS in hospital healthcare settings. However, there is a lack of knowledge about transfer

and retention of the HFS developed, from SBT to actual competencies in clinical practice. The culture of viewing HFS as innate and complicated to train could be one of the obstacles. More research is required to increase knowledge about the transfer of competencies to daily clinical practice.

Limitations

A few limitations of this review need to be highlighted. Firstly, three authors screened an extensive number of studies, but only the first author did a full-text reading and assessment of the included studies. This increases the possibility of selection bias and influenced the internal validity. The bias was sought to be minimised by bringing any doubts about selected studies to the wider author group. Nevertheless, the intercoder reliability is inevitably affected when human coders are used in content analysis (128). Secondly, the Hawthorne effect (alteration of behaviour simply because HFS were studied) represents a possible bias (130). Thirdly, 48% of the participants in the included studies courses were volunteers, but the results from volunteer studies do not deviate from the enhancement among mandatory participants. Nevertheless, the number of volunteers could lead to a positively biased result because they agreed to SBT as a learning method. Finally, the results may be influenced by publication bias, because studies with unfavourable results of SBT might not have been published, which could mean an endorsement of the results in the direction of a favourable analysis.

Implications for practice

It is evident that SBT can improve qualified personnel's HFS. SBT is an effective learning tool, for use with novices as well as experts, and with unqualified or qualified personnel. A change of focus is recommended for healthcare providers not only to train emergencies or rare situations, but also everyday non-emergency situations, such as admission to hospital, rounds, or the unprepared talk with next-in-kind in the hallway. This

review shows that even qualified personnel can develop their HFS significantly through SBT.

All human interactions in hospitals need to be efficient and trained just as seriously as TS and clinical procedures because interactions are just as prone, if not more, to errors. Cultural, social and people skills, together termed HFS, are not innate and untrainable. Rather, they are generic and important in reducing adverse events within healthcare and demands an increased focus on systematic multidisciplinary training of HFS among healthcare teams.

List of abbreviations

AMSTAR-2: a measurement tool to assess systematic reviews – 2nd edition
ANTS: anaesthetists' non-technical skills
CASP: critical appraisal skills programme
CINAHL: cumulative index of nursing and allied health literature (database)
COVID-19: coronavirus disease 2019
COVIDENCE: an online tool that streamlines parts of the systematic review process.
CRM: crisis resource management
EBSCO: Elton B. Stephens company (online access)
EMBASE™: Excerpta Medica database (database)
ERIC: educational resources information center (database)
HFS: human factor skills
MMAT: mixed methods appraisal tool.
MEDLINE: medical literature analysis and retrieval system online (database)
NTS: non-technical skills
Non-RCT: non-randomized controlled trial
OVID: part of the Wolters Kluwer group of companies (online access)
PICO: problem/population, intervention, comparison, and outcome
PROSPERO: prospective register of systematic reviews
PRISMA: preferred reporting items for systematic reviews and meta-analyses
PsycINFO: psychological information (database)

RCT: randomized controlled trial

SCOPUS: Elsevier's abstract and citation database

SBT: simulation-based training

SPICE: setting, perspective, intervention, comparison, and evaluation

TS: technical skills

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Supplements

Supplement A (search history) available at:

https://syddanskuni-my.sharepoint.com/:x:/g/personal/lebahn_sdu_dk/EU-WiNRBREVFJhd1gdx2SsyIBrCK040WofXe6bV_s1-74Dg?e=UgHInw

Supplement B (full summary of studies) available at:

https://syddanskuni-my.sharepoint.com/:x:/g/personal/lebahn_sdu_dk/Ef-YS7hErE1BiP4SfaEBtHUBWYz9u-Z5jC6e8R0nP1pTwQ?e=JmcPIm

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Article D: Beyond *No Interruption Zones* in the medicine room: patient safety through human factors training

(Manuscript version)

Beyond *No Interruption Zones* in the medicine room: patient safety through human factors training

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Keywords: Simulation-based training · Medicine adverse events · Interruptions · Patient safety · Qualitative Health Research · Human Factors

Abstract

Medication errors happen frequently during medicine administration. Inspired by the aviation industry, many hospitals have implemented *No Interruption Zones* (NIZs, i.e., a guideline for not distracting nurses that are administering medicine) in medicine rooms to reduce medication errors. However, unlike in the aviation industry, healthcare professionals do not always have the option of focusing on one task only, for which reason the NIZ is not unequivocally conducive. Nurses are required to coordinate medication administration with other activities in the hospitals, which makes the task both complicated and varied, and which requires that nurses collaborate flexibly in the medicine room. Accordingly, while the NIZ may benefit one aspect of the work, it prioritizes only one of many organizational demands, and NIZs could thus impede flexible collaboration. This article describes a simulation-based training intervention in the medicine room to investigate alternative solutions for supporting both above demands. Nurses are tracked video-ethnographically at four different wards before, during and after going through a simulation training scenario focusing on handling interruptions in the medicine room. Through a hybrid inductive-deductive coding of the video data, it is found that interactions in

medicine rooms are characterized by nurses dealing with distracting interruptions, while at the same engaging in collaborative processes that serve appropriate functions in the hospital. This observation emphasizes that work in the medicine room is constrained by two (or more) conflicting demands. Further, it is found that nurses take roles as leaders and followers as they coordinate activities in the medicine room, especially regarding who is responsible for responding to interruptions. The leader-follower dynamic became evident during simulation training and is interpreted as a way for nurses to adapt flexibly to the interruptions presented in simulation training by protecting less experienced staff prone to making medication errors if stressed. It is concluded (1) that nurses collaborate extensively in medicine rooms to ensure local medicine safety, especially when supporting the most inexperienced colleagues, and (2) that simulation-based training can make health professionals aware of this dynamic in ways that are conducive to safe medicine administration. This result is discussed in relation to current developments in healthcare safety research.

1 Introduction

> As we grow in learning, we more justly appreciate our dependence upon each other. The sum-total of medical knowledge is now so great and wide-spreading that it would be futile for one man to attempt to acquire, or for anyone man to assume that he has, even a good working knowledge of any large part of the whole. The very necessities of the case are driving practitioners into cooperation. The best interest of the patient is the only interest to be considered, and in order that the sick may have the benefit of advancing knowledge, union of forces is necessary. (Mayo, 1910)

When nurses prepare medicine in the hospital medicine room, they must ensure that the patient is provided with the correct medication. Medication administration is a challenging task, as medicine rooms are stocked with many different medication types that must be prepared in different ways and often change due to new purchasing agreements and new generic drugs, among other factors. In this article, the term *medication administration* is used for all medicine-related tasks in the medicine room, although medication work

extends beyond the medicine room[2]. Different safety requirements often collide in the medicine room, as shown in Lebahn-Hadidi, Abildgren, Hounsgaard, and Steffensen (2021). On the one hand, there is a requirement to focus and not interrupt colleagues in the often-small medicine room. This requirement is formalized as *No Interruption Zone* (NIZ) guidelines in many Danish hospitals. On the other hand, nurses will maintain friendly and collaborative relationships with colleagues, including helping in the medicine room, especially by looking out for their less experienced colleagues. Collaboration in the medicine room is formalized as rules of teaching obligations, but also represents an informal nursing culture of collegial support and concern that all patients in the ward receive the correct medicine, not just one's own patients. The colliding requirements of not interrupting and collaborating have been described by ethnographers as different *safety logics* in hospitals, such as a formal safety logic of control and a local safety logic of collaboration (Brown & Reavey, 2017; Ernst, 2016; Ravenhill, Poole, Brown, & Reavey, 2020). The conflict between logics has been shown by human factors researchers to be a source of error when nurses has to choose between interruptive collaboration and non-collaborative non-interruption (Bergström & Dekker, 2014; Dekker & Pruchnicki, 2014). NIZs and collaboration in the medicine room has the same goal of making medication administration a safe procedure by setting checks and balances on the human factors of medicine dispensation and administration, but they build on different ideas of how safety looks. From the perspective of collaboration, safe medication administration is a local achievement through helping and checking colleagues. From the perspective of the NIZ, continuous interruptions, even good-faith interruptions to help, create task-switching and less focus on medication administration. Here, safe medication administration is thus thought of as the suppression of interruptions.

This article sheds light on the interaction between the two safety logics of collaboration and non-interruption, as they are enacted and prioritized by nurses in Danish hospital medicine rooms, and further how human factors training with simulation scenarios affect these logics. It picks up on two previous studies conducted by the authors. As shown in AUTHOR (Submitted), simulation-based training improves human factors such as

[2] Medication administration is defined as the processes, in which healthcare professionals are prescribing, dispensing, distributing, and assisting the patient with the intake of medication, including performing the necessary observation of the patient.

coordination and communication between nurses. Second, as demonstrated in Lebahn-Hadidi et al. (2021), work in medicine rooms sometimes require intensive coordination and communication. In this article, it is hypothesized that simulation-based team training is beneficial for nurses in medicine rooms, and that training has the advantage over NIZs of not reducing safety to a question of blocking interruptions. From this assumption, two questions are examined: what is the scientific rationale, aim and evidence behind the adoption of NIZs in hospital medicine rooms? To answer this first question, examples of NIZ experiment studies and an overview of literature reviews in the field is provided. Based on the overview of interruption prevention research, it is further asked: how can simulation training of human factors, such as coordination and communication, qualitatively change nurses' medicine administration? To answer this second question, we investigate the interactions inside medicine rooms of two Danish hospitals video-ethnographically. The collaboration of nurses in medicine rooms under NIZ rules is described along with an analysis of how the pattern of collaboration changes when nurses are exposed to a simulation-based training scenario specifically focused on handling interruptions. Changes to the interaction in the medicine room is analyzed through a qualitative coding of video data, leading us to identify an overall pattern of team coordination in medicine rooms where nurses take on roles of leaders and followers to safely administer medicine. We argue that simulation-based training of human factors strengthens this pattern of role-taking among nurses, thus enhancing local safety measures. In the last section, the broader applications of the findings in the light of recent developments in healthcare safety research is discussed.

2 The science of *No Interruption Zones*, a critical review

The danish case hospitals of this investigation has implemented NIZs in all medicine rooms. The literature revealed that many other hospitals worldwide has taken similar steps to reduce interruptions with the goal of making medicine administration safer. But does the NIZ work and how did researchers come up with the intervention? In this section, a brief and critical overview of the science of healthcare interruptions and interruption prevention experiments is provided.

The medicine room NIZ goes by several names. It is also known as an *interruption-*, *disturbance-* or *distraction-free zone*. It is a relatively recent invention that is modelled after the aviation industry's sterile cockpit rule (Hohenhaus & Powell, 2008). The sterile cockpit is a widely adopted aviation regulation stating that no flight crewmember may engage in any activity during a critical phase of flight, which could distract from the safe operation of the aircraft. The aviation regulation apparently inspired researchers of healthcare interruptions to experiment with a similar method for suppressing interruptions in hospital medicine rooms (see also Anthony, Wiencek, Bauer, Daly, & Anthony, 2010). The reason for the need to suppress interruptions was the increasing evidence that nurses are interrupted often during critical medication administration (Alteren, Hermstad, White, & Jordan, 2018) and that "interruptions have been shown to lead to medication errors" (Colligan & Bass, 2012, s. 912). Interruptions have been found through observational studies to be associated with an increase in the frequency of medication administration errors (Scott-Cawiezell et al., 2007; Johanna I Westbrook, Raban, Walter, & Douglas, 2018; J. I. Westbrook, Woods, Rob, Dunsmuir, & Day, 2010). Non-human interruptions (such as alarms) have also been shown to increase patient hazards such as delays in care, breaks in task protocols, and other patient safety issues (Drews, Markewitz, Stoddard, & Samore, 2019). Also, it has been shown that some nurses perceive interruptions as the source of error and patient harm (Schroers, 2018). Still, reviewers of the field find that there is still a lack of evidence for how interruptions affect medicine administration with most studies lacking fidelity and reliability (Sanderson & Grundgeiger, 2015). Another review shows that interruptions are frequent in healthcare but that only few studies describe the impact of interruptions for clinical practice and patient safety, with most papers only measuring the interruptions themselves (Monteiro, Machado Avelar, & Pedreira, 2015). A common criticism among reviewers of research into healthcare interruptions is that researchers often do not consider their own biases about interruptions. Typically, interruptions are conceived of as purely adverse events:

> The current findings suggest that beliefs about the ill effects of interruptions remain more conjecture than evidence-based. Pre-existing beliefs and biases may interfere with deriving a more accurate grasp of interruptions and their effects. Future research would benefit from examinations of interruptions that better capture their complexity,

> to include their relationships to both positive and negative outcomes (Hopkinson & Jennings, 2013, 38)

Despite such ongoing validity criticisms of the methods and evidence, a popular area of intervention has become the *'Do not interrupt' bundled intervention*. This concept refers to introducing several different types of behavioral *cues* (also called *nudges*) in hospital wards and observing if interruptions drop as a result. The bundles typically include warning signs around medicine rooms, red tape on the floor around medication carts and areas, nurses being instructed to wear warning vests, tabards, and lighting lanyards, and even warning lights on medication carts and on doors. These interventions aim to signal the existence of a NIZ that should discourage interruptions of the nurse inside the zone.

Let us go through a few examples of these experimental intervention studies: J. I. Westbrook et al. (2017, 740) found that a bundled intervention caused a significant reduction in interruptions but did not assess if fewer adverse events also followed. They also reported that most nurses did not like wearing the vests, finding them cumbersome and time-consuming. Freeman, McKee, Lee-Lehner, and Pesenecker (2013) also measured a drop in interruptions after a bundled intervention, but not the connection to harm. They found that the medicine room was a casual conversation place that became "much quieter" after the introduction of a NIZ. However, the medicine room gradually returned to being the "water cooler" of the ward, meaning a place for private small talk. They also report that nurses did not comply with some the interventions; some nurses refused to wear red lighting lanyards because they had a negative influence on other parts of their work, for instance by accidentally waking up patients. A third NIZ study by Anthony et al. (2010, 25) showed similar effects as the other two, that is an overall drop in interruptions. In this study nurses were observed in secret with no knowledge of the study aims. If nurses were to ask why there was red tape on the floor or why they were being observed, the observer was instructed to "respond with a general description of a patient safety initiative focusing on documenting practice issues such as handwashing, aseptic technique, and proper needle disposal", although the true focus was on medication administration. Paradoxically, Tomietto, Sartor, Mazzocoli, and Palese (2012, 341) found that the number of interruptions between colleagues *increased* after their bundled intervention, perhaps because

nurses on medicine round were instructed to wear a red warning tabard and hereby became more visible to colleagues. Moreover, the authors argue that seeing the red tabard, "patients might be afraid to ask anything and this might delay some important and clinically relevant questions".

Despite the successful decrease of interruptions found in most of the above studies, it is evident that they contain ethical and practical problems of consent, buy-in and compliance from the research subjects. NIZ studies are trying to change the behavior of staff subjects, so problems of subject agency and outright opposition are critical issues and causes for concern. Another problem of the above NIZ examples are the "unintended consequences" (Sanderson & Grundgeiger, 2015) that can follow from trying to reduce all interruptions. For example, a culture of "speaking up" has been shown to reduce medicine errors (Okuyama, Wagner, & Bijnen, 2014). Other studies show that interruptions often contain important information to nurses and are essential to patient safety (Jett & George, 2003; Sasangohar, Donmez, Trbovich, & Easty, 2012). A NIZ intervention might potentially suppress critical interruptions, that is interruptions related to patient safety, such as junior nurses asking for help. As it turns out, many interruptions are essential in the hospital ward:

> Recent interventions, such as 'no interruption zone' signage or artifacts, assume that interruptions are bad and aim to reduce or eliminate all interruptions. These interventions treat all medication tasks as equal; our findings suggest these tasks are not equal. These barriers also assume all nurses are equal and do not allow for the variation in the interruption-handling skill that comes with experience and supports safe medication administration. Indeed, barriers to interruptions may interfere with nurses' ability to select and engage necessary interruptions. This may lead to inefficiencies and care delivery that is out-of-date. (Colligan & Bass, 2012, 915)

Several other reviews confirm the problem of adopting NIZ guidelines that is not based on strong evidence. Raban & Westbrook (2014, 414) find that "there is weak evidence of the effectiveness of interventions to significantly reduce interruption rates and very limited evidence of their effectiveness to reduce medication administration errors. Policymakers should proceed with great caution in implementing such interventions". NIZ studies remain blind to positive effects of disturbances because of the reductionist model

of interruption – they rely on an "epidemiological" research paradigm in which "clinical errors are handled as if they are a 'symptom' of a process that is 'diseased'" (McCurdie, Sanderson, & Aitken, 2017, 26). Within this paradigm, for "a clinician preparing and administering medication, an interruption is a potential pathogen that could compromise the viability of the work process." (McCurdie et al., 2017, 26). This is a reductionist model of interruptions that is being criticized by other branches of interruption research (Sanderson, McCurdie, & Grundgeiger, 2019; Sasangohar et al., 2012). For example, another branch of research argues that interruptions emerge naturally from interactions in the complex socio-technical system of healthcare (Coiera, 2012). Thus, interruptions are needed for constant coordination in a complex hospital environment. They are necessary for safety and should not be eliminated, although interruptions should be limited during high-risk procedures (Rivera-Rodriguez & Karsh, 2010). Further, nurses often develop sophisticated strategies for handling interruptions; strategies that become illegitimate under an "epidemiological" conception of interruptions (Colligan & Bass, 2012).

We do not know why many hospitals have decided to implement NIZ guidelines despite lacking evidence, but it is telling of a vast problem of medical errors, incessant interruptions that is perceived to be the root cause, and a desperate need for better solutions for hospitals. The NIZ has the advantage of being a relatively inexpensive and "easy" solution to implement, precisely because it applies a reductive idea of interruptions. It requires, in principle, only the rewriting of medicine room guidelines and putting up a few warning signs, as we have observed in Danish hospitals. However, it is a solution that lacks reliable evidence, and it can potentially obstruct the sharing of patient safety-critical information in the medicine room. In their recent summary of the field, J. I. Westbrook, Raban, and Walter (2019) concludes that efforts to support nurses and doctors in managing the cognitive load of disruptive environments may be more a valuable route, although it takes more effort and is more expensive, than blanket interventions to reduce interruptions. In line with this conclusion, we propose that supporting the staff, instead of inhibiting them, is a viable alternative approach. In this article we elaborate on this proposal by showing how simulation training in the medicine room strengthens nurses' human factor skills.

3 Method

The above overview of interruption research shows that the NIZ is based on a reductionist conception of interruptions, and that non-reductionist alternatives are needed for supporting safe medication practices in hospital medicine rooms. In this section, the alternative of using simulation-based team training for training human factors and interruption handling in medicine rooms is presented. This method is combined with a qualitative, ethnographic assessment of training outcomes. The training and ethnography were conducted at two hospitals in the administrative Region of Southern Denmark, with two departments at each hospital participating. All four departments were highly specialized with acutely sick patients. All departments had their own medicine room stocked with drugs. The timeline for data gathering and the combination of methods is visualized in Fig. 1.

In the following, the concrete steps of cognitive ethnography, simulation-based training and qualitative analysis is described in detail.

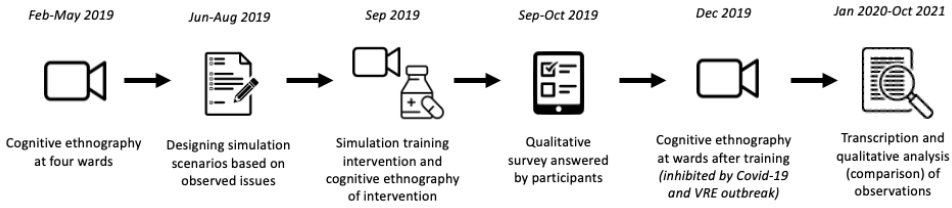

Figure 1: Study method steps

3.1 Cognitive Ethnography

Data gathering were primarily done through the participant observational method of cognitive ethnography by the first and second author. While classic forms of ethnography is based on a naïve empirical realism and an emphasis on independence of theory (Hammersley & Atkinson, 2019), this is not the case with cognitive ethnography. This variant is instead linked firmly to the theory of distributed cognition and extended mind, that is, theories of how humans cooperate with their environment when working on tasks (Ball & Ormerod, 2000, 2017; Sutton, 2006). Therefore, cognitive ethnography is a more

focused form of ethnography that zoom in on how humans link with their environment to perform specific tasks. Instead of focusing on culture, the method aims at tracing tasks that move across humans and systems (Hutchins, 1995, 2010). In this case, the traced task was medicine administration and how staff dealt with disturbances of medicine administration. Specifically, the first and second author followed nurses, doctors and assistants with a video camera and asked clarifying and phenomenological questions during work. The combination of video-based observation and questioning, including the limitations, is discussed in Lebahn-Hadidi et al. (2021).

Approximately 112 hours of video were recorded in the hospital departments with 53,5 hours allotted before simulation training, 51 hours during training (training was recorded from three angles, 17 hours of training in total), and 7,5 hours after training. We were not able to gather more data after training due to a breakout of Vancomycin-resistant Enterococcus at one hospital and later the Covid-19 pandemic.

3.2 Simulation-based training

From the initial ethnography at the four hospital departments, it was assessed that interruptions were a frequent phenomenon during medication administration, even though departments had implemented NIZs in and around medicine rooms prior to this investigation. When asked, interruptions were also a key issue that managers and staff both pointed to as problematic and requiring of research. Based on these observations and statements, we designed a simulation-based training scenario centered on the handling of interruptions and how nurses manage them in the medicine room. The scenario guidebook can be found in Supplement A. The simulation scenario was built on the CAMES model, developed at Rigshospitalet in Denmark and based on the principle of *non-judgmental debriefing* from Rudolph and colleagues (2006; 2008; 2007) and with a focus on developing social and human factors, also known as *non-technical skills* training (Dieckmann, Sharara-Chami, & Ersdal, 2020; Dieckmann, Zeltner, & Helsø, 2016). The participation was voluntary for the staff at the department and was presented as a self-improvement and learning opportunity and not as a test. Scenarios were led by two trained instructors, while the first and second authors were observing and recording with video cameras. Nurses were given roles

according to their qualification level in the training scenario (e.g., a student would not simulate an experienced nurse). Instructors would sometimes introduce deliberate interruptions in the medicine room according to the scenario guidebook (see Supplement A), such as a training confederate asking a question through the medicine room door. Shortly before the training scenario, participants were first briefed about the scenario setup and the training goals of improving human factors skills and handling of interruptions. Participants were then given a medication list for a fictitious patient, although the list was medication adapted from a real medication list from the department (see Supplement A). The participants then had to find and prepare the medication in the medicine room. The scenario lasted about 10-15 minutes and were followed by a 20-30-minute debriefing in a separate room afterwards.

61 nurses, students, health assistants and doctors participated in training scenarios across the four departments. Of these, 44 responded to a qualitative survey about their training experience distributed afterwards. Data consists primarily of video recordings of work interactions before and during training, as well as video recordings of the debriefing sessions after training. Sections of the video has been transcribed for qualitative analysis below. The transcriptions are supplemented with field notes from the first and secondary author and with first-person descriptions and evaluations from the qualitative survey, answered by participants after training.

3.3 Qualitative analysis

The starting point for this analysis is all interactions that happened in the medicine room. Therefore, the first author watched through all 112 hours of collected video, noting all video sections from medicine rooms in a table for further analysis. Analytically, these video sections where then approached from a qualitative, enactive approach, with some elements of grounded theory, for describing, coding, and interpreting data. This method was inspired by Hutchins (2010, 438-440), Stilwell and Harman (2021), and Charmaz (2006). The enactive approach emphasizes four phases of analysis: 1) deductive description, 2) inductive coding, 3) constructing a messy situational map, and 4) constructing a categorized situational map. The goal is thus to develop a pattern through an interpretive

process that is both deductive and inductive. Below, we go through the concrete actions of each of these steps.

The first phase is deductively describing the interactions in the video data from the perspective of distributed cognition and enactivism, that is a description of how cognition plays out within the observed interactions. The enactive framework means that descriptions should focus on how agents perceive their environment through action, that is *enacts* their experiences (Noë, 2004). Such a distributed, enactive description is exemplified in the second column of Table 1. Importantly, applying enactivism does not produce objective descriptions, but is an interpretive exercise. According to Thompson (2007, 423), Varela had been using the term "the hermeneutic approach (to cognition)" before settling on "enactivism" – both Thompson and Varela are considered founders of the school of enactivism. After the description phase, the second phase is the inductive coding of the video data (Stilwell & Harman, 2021, 12). This step is an intuitive, interpretive process of

Researcher, video data	Deductive (enactive) description	Inductive (intuitive) codes
Author 1, video data anonymized	Interruption between two experienced nurses (Fie & Mats). Fie asks if Mats forgot third nurse's noradrenaline. Fie thus checks if Mats is integrated in cognitive network. Mats finishes task before turning head towards Fie. Mats must clarify several times what Fie is referring to. Confirms inclusion. Conversation ends with micro-voicing strategy: humming and phasing out voice.	Interruptions removes focus; Kind interruption clarification; Helping colleagues (checking); Collegiality (looking out for); Micro voicing (breaking off conversations)
Author 1, video data anonymized	Interruption between two experienced nurses (Mats & Ava). Mats must move close behind Ava to get gloves. So close Ava cannot move body or turn head. Vocalizes into monitor:"have you eaten?" and talks about her own late lunch in a joking manner, thus diffusing an awkward situation (speculation). This is also coordination, information on when to look after each other's patients (when others are out for lunch) after she has already been interrupted. Ava uses Micro-voicing (humming) when Mats comes close, hereby marks bodily position.	Close interactions in small room; Interruption batching; Collegiality (jokes), Interruption preparation (coordination)

Table 1: Extract of description and coding of ethnographic video-data

generating new codes that reflect the interactions of the video data and the enactive descriptions of the data. The inductive codes are exemplified in the third column of Table 1.

After the description and coding, the third phase is laying out all the inductive codes on a table or in an application such as Powerpoint. This is a tentative situational map, sometimes referred to as a "messy map" (Charmaz, 2006, 119-120) that allows the shuffling around of codes and the interpretive construction of themes. A visualization of the messy, situational map from our investigation can be found in Figure 2, containing all 21 codes generated from the 112 hours of video data. Some codes have been merged because of their similarity already at this step. For example, *learning culture* has been merged with *teaching and learning*.

Figure 2: Situational map, messy working version

The fourth step is then categorizing the codes on the situational map. That means constructing a model of how the codes relate to each other in emerging themes. Again, this in an interpretive, hermeneutic process. Figure 3 illustrates the categorized situational map. Note that some codes fall under more than one category, as prescribed by Charmaz (2006, 120).

As figure 3 illustrates, the two overall categories that emerged from organizing the codes were *distracting interruptions OR collaborative culture* and *medicine room leader*

AND medicine room follower. Thus, this model describes two different patterns at play in the medicine room video data. The first pattern of *distracting interruptions OR collaborative culture* is characterized by a noncomplementary relationship, that is an either-or situation where nurses must make hard choices between preventing interruptions or collaborating. The other pattern, between *medicine room leader AND medicine room follower* is a synergetic relationship, that is a helper-helped situation characterized by nurses taking leader and follower roles in the medicine room. In the analysis below, these two patterns are unfolded by using them as lenses through which to describe the video data. The analysis thus serves to both explain the emerging patterns and to validate their explanatory power when overlayed back on the data from which they were generated.

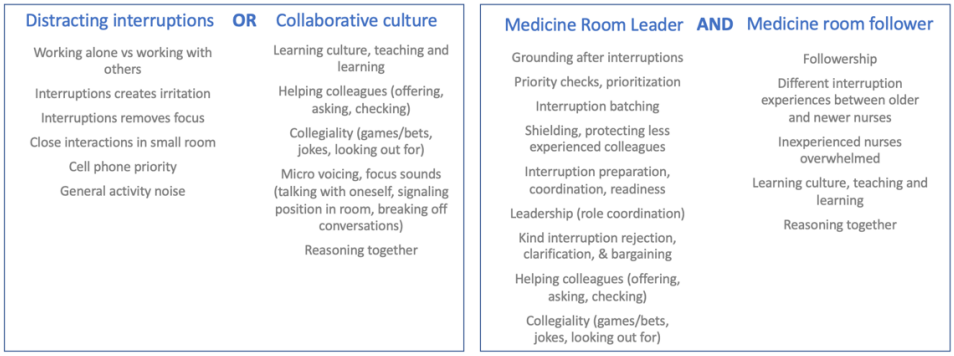

Figure 3: Situational map, categorized version

4 Analysis

In the below analysis, the two emerging patterns are used to analyze the ethnographic video data and the transcriptions of the data from medicine rooms and training. Figure 4 shows video frames from each of the four medicine rooms that constitute our ethnographic scene. The door to each medicine room is locked and can be opened with a staff ID card. The rooms are small and densely packed with drugs, delivery boxes, cooling cabinets, computers, label printers and other tools and technologies required for administering medicine.

For reasons of conciseness, only a selected number of video examples from the medicine rooms are analyzed, although these examples are chosen for their perceived representativeness.

Figure 4: The scene, four medicine rooms in two danish hospitals

4.1 Distracting interruptions OR collaborative culture

While nurses did emphasize the problem of many interruptions and the nature of the medicine room as an ideally silent space and a NIZ, they would also stress that a culture of help and support existed in the medicine room. In the debriefing after training, one nurse said, "it was good to receive help in the medicine room" and pointed to a culture in the department of "help and feedback in the medicine room". In another debriefing session, a nurse said that helping is "what we usually do". We observed a wide range of collegial ways of supporting each other, from medicine math help to professional wonderments, personal conversations, and even bets and jokes.

During the ethnographic investigation, nurses were observed administering medication in the medicine room. However, most often, several nurses were present at once

because medicine rounds take place at the same time for all patients. Whenever several nurses were present, the medicine room would not be entirely quiet. Nurses were often talking to each other, discussing medicine, or having private conversations. There would also be a level of general activity noise from pillboxes, pill drawers, exhaust devices, and work cell phones ringing. Many nurses pointed to many noises, distractions and conversations in the medicine room and identified these as interruptions. One nurse stated that, "Interruptions create irritation". Still, nurses working together in the medicine room often offer collegial support, sometimes even interrupting colleagues to offer their assistance or insight. In one example, experienced nurses Fie and Mats were administering medication separately with their backs turned to each other. Mats were filling a syringe and had almost finished labelling it when Fie turned around and asked him:

Fie: Are you preparing that noradrenaline? Or are you-
Mats: **Finishes putting the label on the syringe, then turns and looks at Fie** No, no that's-
Fie: Did you forget it?
Mats: Excuse me?
Fie: Dora's patient should have noradrenalin.
Mats: Who?
Fie: Dora's.
Mats: Oh no, no, that is- **waving hand, looks back at the syringe**
Fie: **Waving hand, looks back at monitor** So, she (Dora) fixed it herself.
Mats: No, no. The patient could pause (the noradrenaline) now.
Fie: Oh.
Mats: So that was-
Fie: that was-
Mats: No longer a problem.
Fie: No.
Fie & Mats: **both humming**
Mats: Now I have to- **phases out sound**
Fie: Hm-hm- **phases out sound**

Fie checks if Mats forgot to assist a third colleague (Dora) in this instance. Noradrenaline is a time-sensitive drug, so it is imperative to prepare it before the injection time. The

example illustrates several critical strategies used by experienced nurses to handle interruptions: Mats finished his task of labelling the syringe before turning and talking to Fie. By labelling the syringe *before* addressing the interruption, he would not forget the content of the syringe. Another strategy evident in the example was humming and phasing out of sound to disengage from the conversation and focus on their work. Humming and clearing one's throat was also common when nurses moved close to each other and seized pills behind colleagues' backs. It can be dangerous to walk behind nurses carrying syringes and drugs in the medicine room, so this type of micro voicing had an important function of communicating the position of nurses close to each other. As we see, micro voicing (such as humming) can also mean that an interrupting conversation has ended. For example, when a nurse asked a pharmacist who was filling up cabinets in the medicine room, "By any chance, do you have some twenty-millilitre syringes on that table?". The pharmacist answered "no", but shortly after, the nurse spotted the syringes at the other side of the room and uttered "Ah!" to indicate that she no longer needed help from the pharmacist.

One time we observed a nurse walking close behind another nurse without giving any verbal signal such as humming. The other nurse became surprised that somebody was behind her and said "oops". This wording illustrates how it can be surprising and possibly dangerous if nurses would not be aware of the location and activity of other nurses in the small room. Thus, it was more common for nurses to hum, clear their throat, or make other sounds such as "hmmm" when walking behind other nurses or reaching in front of them for drugs as a form of local safety making.

In another example, a male nurse, Mats, had to walk very close to a female nurse, Ava, because the glove box was located behind her head. As Mats was standing very close behind her, Ava uttered:

Ava: Have you eaten?
Mats: No, what about you?
Ava: I took a lunch and some caffeine. Dum dum.
Mats: **Smiles** So late (in the day)
Ava: Yeah, we had to transfer a patient from room four.

In this example, Mats moving close behind her interrupted Ava, and she issued a personal conversation about lunch. Besides perhaps relieving the awkward situation of standing too close to each other, the personal conversation also served another purpose. In Ava and Mats' department, patients cannot be left alone, so lunches have to be coordinated for nurses to look after each other's patients. Therefore, the conversation is also part of the daily coordination where nurses need to know who can support them and when. Besides making the medicine room a friendly space that is not awkward, we can see Ava's conversation as a type of interruption batching: she has already been interrupted, so she coordinates with her colleague now that their attention is already not on the medication administration.

The pattern of interrupting and cooperating with colleagues was also present during our simulation training. For example, the experienced nurse Dorthea had to interrupt the similarly experienced nurse Maya because she had to look inside a drawer where Maya was standing. Maya let Dorthea open the drawer by walking backwards and then asked:

Maya: What do you need?
Dorthea: (Medication name)
Both look inside the drawer
Maya: Hmm. But that has another name.
Dorthea: It has another name. There!
Maya: Yes!

In this way, the nurses would cooperate after the interruption and resolve the problem quickly together. Later during this training exercise, the nurses would again draw on the competence of each other:

Maya: Listen, Dorthea, there's something I would like to ask if I can disturb you.
Dorthea: Yes?
Maya: Because here it says '(medication name)' and it says 'dosage'
Dorthea: Three milligram
Maya: Three plus three plus five plus three. What does that mean?
Dorthea: Three plus three plus five plus three.
Maya: Is that how to read it?

Dorthea: Yes, I think so. But we don't have three milligrams.

Maya: No, we haven't.

Dorthea: We only have five or ten (milligram) if I remember correctly. (…)

Maya: You know what, I'll make a call (to the doctor). Three milligrams does that even exist?

Dorthea: No, I don't think it does.

Maya: **Turns to her monitor, hums**

Dorthea: **Turns to her monitor** I need to **phases out voice**

Again, we see the pattern of interrupting to collaborate and disengaging from the collaboration by humming and micro voicing. It was, however, only in training exercises that we saw nurses specifically ask each other if they could be interrupted pointing to a heightened awareness of interruptions created by the simulation setting. In the debriefing after training, both Maya and Dorthea specifically mention that the above collaboration was a positive experience. Maya said that "I think the help we had between us **points to Dorthea** it was- yes. We reasoned our way to the same result, I think, more or less." There was, however, also a nursing student, Justine, present in this scenario, and the two experienced nurses had a different idea about interruptions in relation to Justine. In the debriefing session, they explained:

Maya: Interruptions are not negative in and of themselves. We do talk to each other even though, one might say, it's a forbidden area for talking.

Dorthea: I think it depends on how experienced you are.

Maya: Yes.

Debriefer: How so?

Dorthea: If you are new and must concentrate on 'how is this done?', all these things, and 'am I doing it correctly?'. Then you are entirely focused on that. Old rats can do it automatically **smiles**

Maya: That is something I consciously think about in the medicine room: it depends on whom I am sharing the room with. If I know it's a student or new nurse, then I'm usually not for small talking.

Dorthea: No. (…)

Debriefer: So, it would be other things you would ask about if Justine (a nursing student) was in there?

Justine: Then it would probably be me who was asking them.

Dorthea: I don't think I would interrupt Justine if she were standing there.

Debriefer: But it would be okay if Justine were interrupting you?

Dorthea: Yes.

Maya: Yes, that is- You almost expect to get interrupted.

Justine: I will do that **laughs**

Debriefer: And there's a safety in that? Do you feel that you can just ask, Justine?

Justine: Yes, I usually just say 'can I ask something?' because if they are in the middle of something they can say 'two seconds' and finish that. And then I can ask. But I feel that I have no overview out there (in the medicine room) of where things are.

In this debriefing, the nurses explain that experienced nurses will collaborate differently with nursing students. Maya also mentions that she is aware that the medicine room is a "forbidden area for talking", and Dorthea specifies that the forbidden area should be thought of in terms of how experienced the nurse is. A more experienced nurse can handle more interruptions, but students and less experienced nurses should be shielded inside the medicine room. Besides again illustrating the problem of working in a no interruption space that requires complex coordination, the idea about 'shielding colleagues' points to the second pattern that we observed in the ethnographic study, that of a medicine room leader and follower dynamic.

4.2 Medicine room leader AND medicine room follower

We had already hypothesized the existence of the noncomplementary pattern of interruptions and collaboration before starting this study and it was confirmed in the above analysis. The second pattern of medicine room leaders and followers was more of a discovery. The leader-follower dynamic became visible in the training scenarios and was explained in the debriefings after training. But as we went back to check the ethnographic data through the lens of this second pattern, we discovered in our video data that the leader-follower dynamic also existed in the everyday medicine administration outside of training. In the data, we observed that more experienced nurses would often take on a leadership role in the medicine room and help less experienced nurses handle interruptions. The leader often showed sophisticated techniques for handling interruptions, some of which we have described in section 4.1 above: batching several interruptions together, checking

the priority of interruptions, preparing for interruptions, thoughtfully rejecting some interruptions, bargaining with the interrupter and clarifying interruptions before engaging, and finally grounding themselves after an interruption by taking a few seconds to recall when and where in their medication administration process they were interrupted. On the other hand, less experienced nurses, as followers, would emphasize the complexity of medication administration and medicine math, stress the importance of receiving help from more experienced nurses, whose orders they were happy to follow, and a feeling of being overwhelmed by the sheer number of drugs in the medicine room. For example, a student emphasizes in training debriefing that he was happy that an experienced nurse took responsibility: "I did not doubt that she knew where we were in the medical process."

An example of the leader-follower dynamic in one training scenario was between the two nurses Marianne and Anne. Marianne was a senior nurse but new at the department, and Anne was a senior nurse with many years at the department. Marianne had been walking around the medicine room for twenty seconds, trying to locate a specific drug on her medicine list. She then sought Anne's help, although there were two other nurses in the room. Anne was the most experienced. Anne was filling up a syringe when Marianne put a hand on her back:

> **Marianne:** Do you have time for a question?
> **Anne:** Yes. **Puts down syringe**
> **Marianne:** (Medication name)
> **Anne:** Yes. We have that right here. **Opens drawer, points to the drug, walks back to her station**

In this way, Anne prioritized helping a colleague over her work, perhaps because she knew that Marianne was new at the department. However, Anne's help extended beyond that short interaction as she now took even more responsibility: as Anne walked back to her station and syringe, she turned around and checked visually that Marianne had indeed picked up the correct drug. She noticed that Marianne had picked up the wrong type of drug, so she walked back to Marianne. Anne put her hand on Marianne's back and switched Marianne's pills on the table with the liquid medication in the drawer while saying, "I think, we actually just use this". Anne then walked back to her station again but

turned around yet again, pointing to the liquid drug while saying: "and it was one gram, yes", now checking if the concentration of the drug is correct. Anne thus showed leadership by taking responsibility for Marianne's medication administration in this situation, helping and checking her several times, and thereby avoiding a potentially adverse event.

In the same training scenario, a simulation confederate looking for a key interrupted the nurses in the medicine room. All nurses looked toward the interrupter in the doorway, but the experienced Anne walked up to the door and engaged in conversation with the interrupter. She said, "They don't have a key but let us look, there is a board with keys over here. Oh yes, they do have a key. I never heard about that before, but it must be this one." Anne hereby quickly resolved the interruption and shielded the other nurses from further interruption by taking responsibility again. In the debriefing afterwards, Anne mentioned as the most positive thing about the training in the medicine room was that she "helped my colleague". Although Anne was happy to help colleagues, she also became aware of her interruptions during the training scenario. Later, she explained her strategy for handling interruptions:

> **Debriefer:** What happens with you when you get disturbed?
> **Anne:** First of all, it's very typical. Especially in the medicine room. What happens is that when I get back to my work, I just have to make a stop **chops the air with her hand**. I just have to find out where I am. How far along in the process am I? Have I done this and this? I just need to get back. I cannot just pick it up because I have lost the thread. But other than that, it's not a problem for me. I mean… It feels like a normal thing **grimaces and laughs**
> **Debriefer:** Is it conceivable for you to say (to colleagues) that you cannot be interrupted?
> **Anne:** Oh, I am far from that.
> **Marianne:** I thought about it a lot, that I had to ask you.

We understand from this exchange that Anne, as an experienced nurse, feels a responsibility to help and check the work of less experienced colleagues. She has some strategies for dealing with interruptions, including not getting annoyed and instead grounding herself by stopping and taking a few seconds to get back in the medication administration. This pattern is the same as we saw in the interaction between Maya, Dorthea and Justine above. Another experienced nurse said in a debriefing "I would never

speak harshly to colleagues. I would rather explain that 'you are interrupting me, is it possible to talk later?'." This again points to a dynamic where experienced nurses have a lot of attention on helping colleagues and creating an environment where people feel they can speak up if needed.

Another example of leader- and followership during training was the experienced nurse Clarice who noticed that the junior nurse Heidi mixed penicillin in sterile water, whereas Clarice used saltwater (they were mixing the same penicillin). She interrupted Heidi's mixing to address this but did not correct her. Instead, Clarice had a curious attitude and the two nurses ended up betting who was correct. Instead of lecturing Heidi on the correct liquid for the mixture, Clarice humorously addressed the different mixtures by betting. Clarice later looked up the correct mixture and discovers that both sterile water and salt water can be used. Thus, both nurses learned that they were both correct and maintained a friendly environment. However, it should be remembered that Heidi could have made a mistake and Clarice caught the discrepancy. In the debriefing, Clarice explained that:

> **Clarice:** I looked it up, and none of us made a mistake. (…) I saw that Heidi was mixing with sterile water. I don't know why I saw it. It might have been because we were mixing the same drug, and I saw she took out another mixture. (…) I'm not responsible for Heidi, only if I see her doing something wrong, then I would say it (…). Everybody is here to learn and everybody can make the wrong mixture.

As Clarice points out, she cannot put her finger on why she checked Heidi's work, other than a general culture of helping each other out by pointing out mistakes in a friendly manner. While Clarice does not consider herself an authority responsible for Heidi, Clarice is a leading figure in the medicine room and consider herself professionally responsible for Heidi "if I see her doing something wrong", as she says. After the exchange, Heidi also asks Clarice for her help several times and when Heidi is interrupted by a confederate doctor (as part of the simulation scenario), Clarice also intervenes and helps resolving the doctor's question, even though it was directed at Heidi.

Although the pattern of taking on the leader and follower roles inside the medicine room appeared in training, it was also present during everyday work interactions in our

data. An example of a leader-follower dynamic outside of training was an experienced male nurse (Ryan) who had a student following him. Ryan had already administrated a tray with pills for a patient. While he was administering antibiotics under a ventilation exhaust in the medicine room, his student came into the medicine room to pick up Ryan's pill tray and help him distribute the pills:

Ryan: **points to pill tray** It's over there. Shouldn't he also have some (medicine) at 2 o'clock?
Student: Yes. Can I give him everything?
Ryan: Yes yes.
Student: And this here is the soluble tablet? **holds up big tablet**
Ryan: Yeah, the big one. **Looking over his shoulder at the tablet**
Student: Yes.
Ryan: I think it would hurt to swallow. **smiles**
Student: **smiles** Oh, you think so.

Again, we see a friendly tone and humor between the experienced nurse and the student indicative of the helper relationship that we have clarified above. As an experienced nurse, Ryan is the leader of this interaction and uses humor to help the student remember the directive of not having the patient swallow the soluble tablet. He also checks the student by looking at the soluble tablet, to see if the student is correct. Ryan had no problem being interrupted by the student nurse, in fact, he initiates the conversation immediately after the student enters, again pointing to a priority of leading less experienced colleagues safely through their medication administration.

4.3 Overall pattern: medicine room coordination and training

Before our simulation-based training, we observed the pattern of distracting interruptions OR collaborative culture. This pattern corresponds well to our description of incompatible safety logics of medicine room work in the introduction of this article. However, what was discovered was that the training of human factors in medicine rooms revealed how nurses took on roles to flexibly adapt between interruptions and cooperation. Experienced nurses would often take on the leadership role and less experienced the role of follower. The

pattern of leaders and followers became visible during training but could also be observed when looking back at the ethnographic video data before training. Our interpretation of this emergence of the leader-follower pattern is that simulation-based training of human factors such as interruption handling stresses nurses and requires them to strengthen the leader-follower dynamic that also underlies regular medication administration. Setting up roles is a way of effectively adapting to more interruptions by protecting more vulnerable and less experienced staff prone to making medication errors if subjected to interruptions.

Our analysis points towards a heightened awareness of interruptions and of flexible strategies for dealing with interruptions created by training. Our qualitative evaluation survey, distributed after training, confirmed this interpretation. The survey suggested that the leader-follower dynamic is an embodied strategy learned through experience in the medicine room that only became verbalized and conscious to the nurses through training. As one nurse wrote, "in our collaboration, we didn't think it necessary to choose a leader, but perhaps it could have been an advantage". Nurses who participated in training also wrote that they had become more conscious of interruptions in the medicine room in general. One nurse wrote that "the many interruptions were an aha-moment" and another that "Interruptions takes up a lot of space".

Another trend in the survey was that nurses also pointed to a heightened consciousness of how they interrupted others and had become aware of their habits and strategies for avoiding interruptions. As one nurse wrote, "You become aware of some things that you would not discover so quickly or clearly in daily practice". Another wrote "I became conscious that I interrupted a colleague without reason" and a third that "my frustrations affected the others around me". On a more systematic approach, a nurse wrote that "I became conscious, that I actually use some kind of systematic approach" and another that training "made conscious bad and good habits in your everyday work and how you by becoming aware of them can go from habit to a systematic approach". A general theme of the survey was that nurses had been surprised with how training had revealed hidden skills for dealing with interruptions and how interruptions are more pervasive than they thought. As one nurse concluded, "the non-spoken has to become spoken," and simulation-based training offers an opportunity for that.

5 Discussion

The analysis in Section 4 shows that nurses collaborate extensively in the NIZs of medicine rooms to ensure medication safety. The primary pattern of safety making is that of taking leader and follower roles organically in the medicine room, where the leader will be somewhat responsible for interruptions and helping less experienced nurses with medication administration. The leader is not an authority (a manager) but rather a professional leader (i.e., a person who shows the way). Nurses working in the medicine room are exposed to both external interruptions (people coming in the door, alarms going off outside, cell phones ringing) and internal interruptions of collaboration, coordination, and self-interruptions. The nurse leader takes on themselves many interruptions and questions from their followers of the medicine room.

Simulation-based training of human factors in the medicine room highlighted the above leader-follower dynamic of medicine room work. In human factors training that deliberately introduces disturbances and interruptions, the need for a medicine room leader became even more critical to negotiate the interruptions with the interrupter and help the less experienced nurses with their medication administration by shielding them from external interruptions. Our ethnographic investigation and simulation-based training intervention confirm the reductive nature of NIZ guidelines and bring even more attention to the conflicting demands on nurses in the medicine room. Adverse events will happen as long as the hospital organization put conflicting demands on nurses at the sharp end of the medical system (Dekker & Pruchnicki, 2014). However, solutions such as simulation-based training is a pragmatical approach that emphasizes training how to work in an environment of conflicting demands. Training in the medicine room makes staff conscious of the different demands. It lets them teach each other best practices and personal coping strategies, developed over many years of experience, for both avoiding interruptions and helping colleagues at the same time.

Hollnagel and colleagues (2013; 2015, 10-12, 21) explain how guidelines such as the NIZ in medicine rooms are expressions of a so-called *Safety-I* paradigm, where "the starting point for safety management is either that something has gone wrong or that something has been identified as a risk. Both cases use the 'find and fix' approach". The idea is that error is a product of erroneous processes that must be stopped, which is the exact paradigm

underlying the implementation of NIZ guidelines. However, as the authors point out, such an idea of safety is contradictory "because safety is being defined by its opposite, by what happens when it is absent rather than when it is present". Several problems arise from a Safety-I paradigm, including blindness towards the local safety-making practices observed in the medicine room in this article. Instead, the authors argue for the alternative *Safety-II* paradigm, in which "we should avoid treating failures as unique, individual events, and rather see them as an expression of everyday performance variability". The idea is that when something goes wrong, it is usually the outcome of a process that usually goes right and has succeeded many times. Failure is, therefore, not due to bad performance specifically, but instead a feature of variable human performance where catastrophic accidents are one end of the spectrum and surprisingly excellent performances are located on the other end. Safety-II is a more relevant paradigm for modern healthcare safety because it acknowledges the complicated socio-technical system of healthcare, where situated human performance is endlessly varied and different. We have shown in Lebahn-Hadidi et al. (2021) that it is precisely through variable and intentional micro-processes that nurses create safety on a local level. We build on this insight here and argue that simulation-based training of human factors is a way of strengthening and making conscious the skills nurses need for varying their medication administration performance in the face of interruptions. Simulation-based training might not be the only way to become aware of performance variability in the medicine room. Alternatives could include focus groups, workshops, reflection exercises, coaching, psychological help, and feedback sessions for nurses and other qualified personnel. In other words, a stable and safe medication administration requires a reflexive and learning-based approach to medication administration.

NIZ guidelines and other Safety-I approaches are not a shortcut to a reduction in medication administration adverse events but can instead lead to new patient safety problems. Instead, more initiatives that support local safety-making is needed. The safety innovator Paul O'Neill, famous for achieving close to total safety in the notoriously dangerous steel industry and later a healthcare safety advisor, suggested that hospitals could only achieve total safety if each person in the workforce could answer affirmatively to these three questions each day: 1) I am treated with dignity and respect, 2) I have what I need, including training, and 3) I am recognized for what I do. (LLI, 2013, 14). Simulation-

based training is part of a move towards providing nurses with the human factors skills that they need to avoid interruptions in the medicine room, instead of simply ordering them to avoid interruptions that could contain important patient safety information. Debriefings after simulation training also provide a way to recognize the hidden teamwork skills that nurses have and use in the medicine room.

Based on our investigation, we suggest focusing on training, feedback, and debriefing that provide nurses with tools for overcoming interruptions and adverse events, make conscious and qualify their interruptions rather than heedlessly suppressing interruptions. We have shown that nurses put much work into helping, teaching, and learning about medication administration in the medicine room, and simulation-based training supports this process. As one nurse wrote in the evaluation survey, simulation-based training "is a good culture-maker that opens the department to reflect personally and inter-collegially on workflows". As the epigraph of this article suggests, healthcare was already too complicated over a century ago for individualistic approaches to care quality, and this required healthcare professionals to collaborate extensively. Since then, healthcare has only become more complicated and in order to cope, hospitals have adopted the "spirit of unity" that William J. Mayo (1910) envisioned on all levels of healthcare. Reductions of adverse events in the medicine room will not come from attempts to inhibit the collaborative unity that extends to medicine rooms but from building a learning organization that continually reflects on the human factor skills needed for safe medication administration.

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Supplements

Supplement A (simulation scenario guidebook/curriculum) available at:

https://syddanskuni-my.sharepoint.com/:b:/g/personal/lebahn_sdu_dk/EZFeS5vXaglEqxrN6mTWao4B1klo5fr4_ymfpWJXRKXuoA?e=60RHEP

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English summary

This thesis takes a humanities-based perspective on the widespread medication adverse events that causes much patient harm and increases costs in Danish healthcare as well as globally. The study is based on the question of why safety interventions are not being reconceptualized when they have failed to provide significant reductions in medication errors. Here, the thesis positions itself within current debates among safety researchers who compete on two different proposals for our current predicament in healthcare. On the one hand, the paradigm of *Safety-II* asserts that healthcare problems stem from a reactive, prohibitive attitude to healthcare adverse events (termed a *Safety-I* paradigm) taken by hospitals. For the proponents of Safety-II, hospitals must psychologically shift to a proactive attitude where nurses and doctors are thought of as resources rather than liabilities. On the other hand, the paradigm of *Safety-III* holds that such a view focuses entirely on the human operator and that a broader systems thinking and engineering of hospital environments is required for total healthcare safety. This thesis combines aspects of both paradigms. It focuses both on psychological, experiential factors that contribute to medication errors as well as systemic factors. It does so by combining phenomenological hermeneutics with distributed cognition in an action research investigation at two Danish hospitals. Through this integrated approach, the thesis produces a situated description of cultural-cognitive ecosystem of medication errors, and it presents a concrete proposal for how to approach medication errors in the future.

The thesis consists of two parts: first, four chapters that summarize the thesis approach and results and, second, four journal articles for scientific publication. In the summary chapters, it is described how the integration of phenomenological hermeneutics and distributed cognition in action research leads to a combination of qualitative methods, specifically cognitive ethnography, Cognitive Event Analysis, phenomenological interviews, and hermeneutic interpretation. The integration allows the thesis to both investigate organizational practice through the experiences of individual organization members and through descriptions of how people, artifacts, technologies, and cultures produce results together.

Next, the thesis comprises four scientific articles. In the first article, the thesis investigates cultural perceptions of healthcare errors through an analysis of popular medical television dramas. It seeks to identify which messages of adverse events are taken-for-granted by the public. From this cultural view, the thesis then zooms all the way in on a single medication error in a Danish hospital in the second article. Through cognitive video ethnography, the emergence of medical error at a micro-scale, in one specific hospital department and with one specific patient, is explored. It is shown how even safe medication administration can produce risk and thus become error-prone over time. Based on both the macro-cultural and micro-cognitive understanding of medication errors, a simulation-based training course for healthcare professionals is constructed and carried out at four different Danish hospital wards. In the third article, the available evidence of the effectiveness of simulation-based team training for improving human factor skills for healthcare professionals is synthesized. The systematic review finds significant evidence that simulation training is an effective way to improve human factor skills. In the fourth article, the application of simulation training inside the medicine rooms of hospital wards is described and evaluated. It is found that medicine administration simulation training increases awareness of interruptions of medicine administration and strengthens nurses' strategies for handling interruptions.

The thesis concludes that medication errors are hard to reduce because they stem from human, organizational and ecosystemic factors. The thesis finds two of such factors of high importance, and that is cultural and cognitive pressures on the hospital organization. On the cultural macro-scale there is a shared myth that healthcare errors are meaningful events from which healthcare professionals can learn and thereby get better at their job. The common sense is that error rates decrease over time, although this is in unrealistic idea of healthcare adverse events such as medication errors, and it can lead to a gap between what the public expects of healthcare and what hospitals can deliver. On the cognitive micro-scale inside two case hospitals, it is found that even safe medicine administration involves an increase of risks in other parts of the work because of the conflicting demands put on nurses administering medicine. This dynamic makes medicine administration prone to error over time. Thus, the hospital organization is both pressured from a public that assumes that error decreases over time and from the interactivity of

everyday medicine administration that inevitably produce some medication errors due to the inherent risk of the medicine administration process.

The thesis also finds that in situ simulation-based team training in general is an effective way of improving the human factor skills of healthcare professionals. Training how to handle interruptions of medicine administration through in situ simulation training improves the awareness of interruptions among participating professionals and can improve professionals' ability to deal effectively with the conflicting demands that are the source of many medication errors. Overall, it is found that in situ simulation team training can be an effective way of addressing the above mentioned cultural and cognitive pressures of medication errors for the hospital organization. It is fruitful for healthcare professionals to prepare and reflect on their own practice. Without careful preparation of and reflection on medicine administration practices, the built-in risks of normal, safe medication administration go unnoticed and can incubate future error. Based on this conclusion, the thesis points towards the combination of phenomenological hermeneutics and distributed cognition as a way forward in humanities-based healthcare safety research.

Dansk resumé

Denne afhandling tager afsæt i et humanistisk blik på de udbredte medicineringsfejl, der forårsager megen skade for patienter og øger omkostningerne i det danske sundhedsvæsen såvel som globalt. Undersøgelsen tager udgangspunkt i spørgsmålet om, hvorfor sikkerhedsinterventioner hospitalerne ikke bliver gentænkt, når de ikke har ledt til en markant reduktion af medicineringsfejl. Afhandlingen placerer sig her inden for en debat blandt sikkerhedsforskere, der diskuterer to forskellige forslag til at forbedre den problematiske situation i sundhedsvæsenet. På den ene side hævdes det under paradigmet *Safety-II*, at problemerne i sundhedsvæsenet skyldes en reaktiv, forbuds-fokuseret holdning til utilsigtede hændelser i sundhedsvæsenet (det såkaldte *Safety-I*-paradigme). Fortalerne for Safety-II mener, at hospitalerne bør skifte til en proaktiv tænkemåde, hvor sygeplejersker og læger betragtes som ressourcer i stedet for passiver. På den anden side mener *Safety-III*-paradigmet, at en sådan holdning udelukkende fokuserer på den menneskelige komponent, og at der er behov for en bredere systemtankegang og et mere omfattende adfærdsdesign af hospitalsmiljøet for at opnå total sikkerhed i sundhedsvæsenet. Denne afhandling kombinerer aspekter af begge paradigmer. Den fokuserer både på psykologiske, erfaringsmæssige faktorer, der bidrager til medicineringsfejl, og på systemiske faktorer. Det gør den ved at kombinere fænomenologisk hermeneutik med distribueret kognition i en aktionsforskning på to danske hospitaler. Gennem denne integrerede tilgang producerer afhandlingen en situeret beskrivelse af det medicineringsfejlenes kulturelt-kognitive økosystem, samt præsenterer et konkret forslag til, hvordan man kan gribe medicineringsfejl an i fremtiden.

Afhandlingen består af to dele: Først kommer fire kapitler, der opsummerer afhandlingens tilgang og resultater, og derefter kommer fire artikler til publicering i videnskabelige tidsskrifter. I de opsummerende kapitler beskrives det, hvordan integrationen af fænomenologisk hermeneutik og distribueret kognition i aktionsforskning fører til en særlig kombination af kvalitative metoder, nærmere bestemt kognitiv etnografi, Cognitive Event Analysis, fænomenologiske interviews og hermeneutisk fortolkning. Integrationen gør det muligt for afhandlingen både at undersøge organisatorisk praksis gennem de enkelte organisationsmedlemmers erfaringer samt skabe beskrivelser af,

hvordan mennesker, artefakter, teknologier og kulturer producerer resultater og fejl sammen på hospitalet.

Hernæst findes afhandlingen fire videnskabelige artikler. I den første artikel undersøger afhandlingen kulturelle opfattelser af fejl i sundhedsvæsenet gennem en analyse af populære hospitals-dramaer på TV. Den søger at identificere, hvilke budskaber om utilsigtede hændelser der tages for givet i offentligheden. Ud fra dette kulturelle overblik zoomer afhandlingen derefter helt ind på en enkelt medicineringsfejl på et dansk hospital i den anden artikel. Gennem kognitiv video-etnografi undersøges fremkomsten af medicinske fejl i mikroskala, på en specifik hospitalsafdeling og med en specifik patient. Det vises, hvordan selv sikker medicinadministration kan producere risici og dermed tendere til fejl over tid. Med udgangspunkt i både den makro-kulturelle og mikro-kognitive forståelse af medicineringsfejl konstrueres og gennemføres et simulationsbaseret træningskursus for sundhedspersonale på fire forskellige danske hospitalsafdelinger. I den tredje artikel sammenfattes den tilgængelige forskningsviden om effektiviteten af simulationsbaseret teamtræning til at forbedre sundhedsfagligt personales 'menneskelige faktorer'-færdigheder såsom ledelse, situationsbevidsthed, osv. Den systematiske gennemgang finder betydelig dokumentation for, at simulationstræning er en effektiv måde at forbedre 'menneskelige faktorer'-færdigheder på. I den fjerde artikel beskrives og evalueres anvendelsen af simulationstræning i medicinrummene på fire hospitalsafdelinger. Det konstateres, at simulationstræning af medicinadministration øger personalets bevidstheden om afbrydelser i medicinadministrationen og styrker sygeplejerskernes strategier til håndtering af afbrydelser.

Afhandlingen konkluderer, at medicineringsfejl er svære at reducere, fordi de skyldes menneskelige, organisatoriske og økosystemiske faktorer. Afhandlingen finder to af disse faktorer af stor betydning, nemlig det kulturelle og kognitive pres på hospitalsorganisationen. På det kulturelle makroplan eksisterer en samfundsmyte om, at fejl i sundhedsvæsenet er meningsfyldte hændelser, som sundhedspersonalet kan lære af og dermed bruge til at blive bedre til deres arbejde. Den almindelige opfattelse er, at fejlprocenten dermed vil falde med tiden, selv om dette er en urealistisk forestilling om utilsigtede hændelser i sundhedsvæsenet som f.eks. medicineringsfejl, og dette syn kan føre til en kløft mellem det, som offentligheden forventer af sundhedsvæsenet, og det, som

hospitalerne kan levere. På den kognitive mikroskala på to hospitaler viser det sig, at selv sikker medicinadministration indebærer en forøgelse af risiciene i andre dele af arbejdet på grund af modsatrettede krav, der stilles til sygeplejersker, der administrerer medicin. Denne dynamik gør at medicinadministrationen tenderer mod fejl over tid. Hospitalet er således både presset af en offentlighed, der antager, at fejl mindskes med tiden, og af interaktiviteten i den daglige medicinadministration, som uundgåeligt fører til nogle medicineringsfejl på grund af den iboende risiko ved medicinadministrationsprocessen.

Afhandlingen viser også, at in situ simulationsbaseret teamtræning generelt er en effektiv måde at forbedre sundhedspersonalets 'menneskelige faktorer'-færdigheder på. Træning i at håndtere afbrydelser i forbindelse med medicinadministration gennem in situ-simuleringstræning forbedrer det deltagende personales bevidsthed om afbrydelser og kan forbedre deres evne til effektivt at håndtere de modstridende krav, der er kilden til mange medicineringsfejl. Samlet set viser det sig, at in situ-simuleringstræning i teams kan være en effektiv måde at håndtere ovennævnte kulturelle og kognitive pres i forbindelse med medicineringsfejl for hospitalsorganisationen. Det er frugtbart for sundhedspersonalet at forberede sig og reflektere over deres egen medicinpraksis. Uden omhyggelig forberedelse af og refleksion over praksis for medicinadministration går de indbyggede risici ved normal, sikker medicinadministration ubemærket hen og kan lede til fremtidige fejl. På baggrund af denne konklusion peger afhandlingen i retning af kombinationen af fænomenologisk hermeneutik og distribueret kognition som en vej fremad i humanistisk baseret forskning i sikkerhed i sundhedsvæsenet.

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