From training to competency

A qualitative investigation of how qualified in-hospital healthcare personnel transfer human factor skills from an in situ simulation-based training course to competency in the complex clinical practice.

PhD Thesis

Lotte Abildgren

2024

Department of Anaesthesiology and Intensive Care, Odense University Hospital, Denmark
OPEN, Open Patient data Explorative Network, Region of Southern Denmark & University of Southern Denmark
Department of Clinical Research, University of Southern Denmark
Emergency Research Department, Hospital Sønderjylland, University Hospital of Southern Denmark
Centre for Research in Patient Communication, Odense University Hospital, Denmark
Centre for Human Interactivity, Department of Language and Communication, University of Southern Denmark
Department of Regional Health Research, Hospital Sønderjylland, University of Southern Denmark

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Preface

This PhD project is the result of a cross-scientific collaboration between health science and social science, which was born after an exploratory discussion between Lise Hounsgaard, Sune Vork Steffensen, Malte Lebahn-Hadidi, and me about how to develop knowledge within the complex process of transferring social and cognitive learning to competency. Before this meeting, Lise Hounsgaard and I had multiple discussions about exploring and monitoring social and cognitive learning to improve patient safety. Establishing the SimLEARN project and collaboration was the first step in the scientific exploration of social and cognitive skills transfer.

My motivation to study this field stems from 25 years as a nurse and 15 years of experience in high-fidelity simulation-based education, clinical education, development, and quality improvement in clinical practice. Both professionally and privately, I have always been interested in interactions and relations among individuals and teams, especially communication and teamwork.

Acknowledgements

This thesis is the end of an incredible personal and professional journey. It has been an exciting journey with ups and downs, sun, and typhoons. However, it has been an enormous privilege. I am most grateful to everyone who has travelled with me and contributed to this goal. Unique and heartfelt thanks to Lise Hounsgaard, whom I met during my MSc in Nursing; we worked together—Lise as a lector and me as a student assistant—in the Unit of Nursing Science, SDU. The journey from the first ideas to the final protocol was long and filled with brainstorming, discussions, and idea proposals. My most profound appreciation goes to my supervisors, Lise Hounsgaard, Sune Vork Steffensen, Palle Toft, and Christian Backer Mogensen, for your support and guidance and for including me in your network. Moreover, thanks to Tove Faber for your supervision during the systematic review.

My gratitude goes to the contributors to the SimLEARN project (departments, facilitators, operators, and participants) and to my colleagues in SimC and Intensive Care, V, OUH. Without you, there would have been no results.

Thank you to my mother, sister, daughters, family, friends, and loved ones for believing in me. Your support and love are priceless. You have been an unbelievable help during the typhoons and great motivators. For challenging me, for my sanity, and for my physical health, I owe Dorte Nees Lamberg and Marlene Mohr an immeasurable thank you.

For financial support, I want to thank the Anaesthesiology and Intensive Care Department, Odense University Hospital (previous and new leaders Ingeborg Moritz Hansen, Jens Schierbeck, Bjarne Dahler-Eriksen, Palle Toft, Jørgen Fisker, and Susanne Sebens Hald); Hospital Sønderjylland, University Hospital of Southern Denmark; and the Centre for Research in Patient Communication, Odense University Hospital.

Thank you!

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List of Papers

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***The effectiveness of improving healthcare teams' human factor skills using simulation-based training: a systematic review, Advances in Simulation*. 7, 1, 18 p., 12 (Abildgren et al., 2022).** Abildgren, L., Lebahn-Hadidi, M., Mogensen, C. B., Toft, P., Nielsen, A. B., Frandsen, T. F., Steffensen, S. V. and Hounsgaard, L.

***Transfer human factor skills from simulation-based training to competency in clinical practice – a demonstration of a hybrid method for assessing transfer of learning*. International Journal of Healthcare Simulation, pp 1-13 (Abildgren et al., 2023).** Abildgren, L., Lebahn-Hadidi, M., Mogensen, C. B., Toft, P., Steffensen, S. V. and Hounsgaard, L.,

***From training to competency – Findings from a qualitative investigation of transferring human factor skills* (Abildgren L; Lebahn-Hadidi) (re-submitted).** Abildgren, L., Lebahn-Hadidi, M., Mogensen, C. B., Toft, P., Steffensen, S. V. and Hounsgaard, L.,

Other Work

Other work was compiled and published during the PhD but not comprised in the PhD project.

Articles:

Nielsen SN, Rudbeck IN, Abildgren L, and Toft P. ***The cardiovascular effect of nimodipine following aneurysmal subarachnoid hemorrhage (aSAH) - A Systematic Review* (submitted).**

Abildgren L., Logadóttir G., Úlfhéðinsdóttir R. L. and Toft P., (2023). ***The Effect of Sedation on Renal Function in ICU Patients: A Systematic Review***, Annals of Clinical Anesthesia Research. 7, 1, no. 1048 (Abildgren L et al., 2023).

Lebahn-Hadidi, M., Abildgren, L., Hounsgaard, L. and Steffensen, S. V., (2023). ***Integrating cognitive ethnography and phenomenology: rethinking the study of patient safety in healthcare organizations*, Phenomenology and the Cognitive Sciences.** 22, 1, p. 193–215 (Lebahn-Hadidi et al., 2021).

Lebahn-Hadidi, M., Abildgren, L., Hounsgaard, L., Mogensen, C. B. and Steffensen, S. V., ***Beyond No Interruptions Zones in the medicine room: Patient safety through human factors training*** (Manuscript) (Lebahn-Hadidi et al.).

Book chapter:

Grundtvig Jensen, T. and Abildgren, L, ***Scenariedesign*, in: Simulation i sundhedsvæsenet**, red. Hallin, SP., Lippert, A. and Østergaard, D. [Danish] Chapter 8 (In press).

E-learning program:

Refresh your debriefing skills for beginners and trained simulation facilitators with a simulation-based training facilitator course [Danish].

From simulation-based training of human factor skills to competency in clinical practice

Summary in English

Introduction: This PhD thesis developed knowledge on qualified in-hospital healthcare personnel's transfer of human factor skills to competency in clinical practice. The topicality was based on the fact that patient safety is crucial in modern healthcare. Further, in 2019, the World Health Organisation emphasised patient safety as a fundamental area of attention. Research and existing efforts focus on preventing adverse events and emphasise learning from errors to improve healthcare practices. Despite the effort, the number of reported adverse events in Danish hospitals has stabilised instead of reduced. The economic and human impacts of adverse events on healthcare underscore the necessity of attending to cognitive, social, and psychological factors (human factor skills) influencing patient safety.

Background: The approach to learning from errors primarily focuses on providing knowledge and procedures to reduce errors. In recent years, training in acute critical situations has also been used to improve patient safety. Existing research indicates that simulation-based training enhances the knowledge and skills of pregraduate healthcare students and that participants through simulation-based technical skills training demonstrate advancement along the learning curve when applying the skills in clinical practice, compared to no training. However, whether this result could be applied to human factor skills is unknown. A systematic review was conducted to investigate the effectiveness of training qualified healthcare personnel's human factor skills through simulation-based training. The findings support the applicability of simulation-based training to enhance human factor skills. Still, the process by which the taught and trained skills are translated into clinical practice competency remains unclear. This revealed a scientific gap regarding transfer of human factor skills from simulation-based training to competency in clinical practice.

Aim: This PhD study aimed to develop knowledge of how qualified healthcare personnel within a hospital setting transferred human factor skills acquired through a simulation-based training course into everyday clinical competency. The personnel's human factor skills competency was investigated before, during and after a simulation-based training course. The aim was based on the following overall research question: *How do qualified healthcare personnel transfer human factors skills taught and trained in an in situ simulation-based training to competency in everyday clinical practice*?

Method: The study comprised a qualitative research design and was methodologically and theoretically informed by the assumptions of phenomenological-hermeneutic based on Ricœur's critical hermeneutic. The study's complexity in capturing physical, psychological and sociocultural changes in qualified healthcare personnel was built upon several theoretical frameworks within the quality of care, didactics and transfer. Ethnographic fieldwork was used to investigate the personnel's transfer of human factor skills. A hybrid analytical method (RI-CEA) was developed to explore how transfer emerged. RI-CEA comprised a Ricœur-inspired analytical approach and Cognitive Event Analysis, which enabled a 1st and 3rd person's perspective on data.

The ethnographic data was collected between February 2019 and February 2020 and included approximately 107 hours of video recordings, field notes, and written reflections.

Findings: The systematic review highlighted the need to reconsider the focus on transferring human factor skills. Numerous assessment tools have been developed to render human factor skills visible for modifications during and immediately after simulation-based training. The systematic review asserted the effectiveness of training human factor skills among qualified healthcare personnel, but challenges in appraising human factor skills development impede comparisons of effectiveness. The perception of human factor skills as innate and challenging to train persists, posing a potential obstacle in transitioning human factor skills from simulation-based training to competency. This conclusion served as a foundational understanding for the subsequent ethnographic study.

The ethnographic study comprised three phases: Clinical phase (before), Simulation-based training phase (during) and Transfer phase (after). The naïve reading of the data from the Clinical phase revealed a highly switchable clinical practice. The analytical themes of coordination, interruptions, educational responsibilities, teamwork, and situational awareness were integrated into the training course in the following phase. The simulation-based training phase underscored the importance of training. Participants expressed a focus on technical skills but lacked emphasis on or practice of human factor skills in the everyday. The structural analysis identified the themes of educational responsibilities, feedback, decision-making, leadership, and teamwork, shaping the focus in the subsequent Transfer phase. The Transfer phase revealed engaged qualified healthcare personnel open to human factor skills training and emphasised positive interest. However, challenges included the lack of human factor skills-language, time constraints, and a dilemma between wanting to improve human factor skills and the experience of lack of priority among colleagues and organisations.

The analysis found three key transfer levels: Individual, Intercollegiate and Organisational transfer of learning. These interconnected and interdependent levels shed light on the limited extent of human factor skills transfer after simulation-based training. The findings suggested that the acquisition of human factor skills occurred at both individual and intercollegiate levels. However, for adequate transfer, there was a need for organisational awareness and support to ensure that knowledge translates into competency in clinical practice. Inadequate awareness and support for transfer, internalisation, and retention of human factor skills at the organisational level contributed to these shortcomings.

Implications: This thesis explored the understudied transfer process of human factor skills from simulation-based training to competency in clinical practice. Findings suggested a need for a broader training focus, involvement of local human factor skills ambassadors and coordinated planning between simulation centres and organisations to optimise human factor skills transfer and improve patient safety. The research identified areas for further exploration, including

developing a generic transfer strategy, assessing its impact on competency, and investigating the relationship between healthcare personnel's human factor skills competency and patient safety.

Summery in Danish (Resume på dansk)

Introduktion: Denne ph.d.-afhandling udviklede viden om kvalificeret hospitalspersonales overførsel af menneskelige færdigheder til handle kompetence i klinisk praksis. Aktualiteten er baseret på det faktum, at patientsikkerhed er afgørende i det moderne sundhedsvæsen. Desuden understregede WHO i 2019 patientsikkerhed som et fundamentalt fokusområde. Forskning og eksisterende indsatser fokuserer på at forebygge utilsigtede hændelser og lægger vægt på at lære af fejl for at forbedre sundhedspraksis. Trods indsatser er antallet af rapporterede utilsigtede hændelser på danske hospitaler stabiliseret i stedet for reduceret. De økonomiske og menneskelige konsekvenser af utilsigtede hændelse inden for sundhedssektoren understreger nødvendigheden af at beskæftigelse sig med de kognitive, sociale og psykologiske faktorer (menneskelige færdigheder), der påvirker patientsikkerhed.

Baggrund: Tilgangen til at lære af fejl fokuserer primært på at tilføje viden og procedurer for at reducere fejl. I de senere år er træning i akutte kritiske situationer også blevet anvendt til at højne patientsikkerheden. Eksisterende forskning indikerer, at simulationsbaseret træning forbedrer viden og færdigheder hos prægraduate sundhedsstuderende, og at deltagerne i simulationsbaseret teknisk færdighedstræning viser forbedring på læringskurven, når de anvender færdighederne i klinisk praksis, sammenholdt med ingen træning. Men om dette resultat også gælder træning af menneskelige færdigheder er ukendt. Et systematisk review blev udført for at undersøge effektiviteten af at træne kvalificeret hospitalspersonales menneskelige færdigheder via simulationsbaseret træning. Resultaterne understøtter anvendeligheden af simulationsbaseret træning til at forbedre menneskelige færdigheder. Men processen, hvordan de underviste og trænede færdigheder blev transformeret til handlingskompetence i klinisk praksis, forbliver uklar. Dette afdækkede et videnskabelig gap vedrørende transfer af menneskelige færdigheder fra simulationsbaseret træning til kompetence i klinisk praksis.

Formål: Dette ph.d.-studie havde til formål at udvikle viden om, hvordan kvalificeret hospitalspersonale transfererede menneskelige færdigheder, erhvervet gennem et simulationsbaseret træningskursus, til daglig klinisk kompetence. Personalets menneskelige færdighedskompetencer blev efterforsket før, under og efter et simulationsbaseret træningskursus. Formålet var baseret på følgende overordnede forskningsspørgsmål: Hvordan sker transfer af kvalificeret hospitalspersonale menneskelige færdigheder, fra in situ simulationsbaseret træningskursus, til kompetence i daglig klinisk praksis?

Metode: Studiet omfattede et kvalitativt forskningsdesign og var metodisk og teoretisk omfattet af antagelserne i fænomenologisk-hermeneutik, baseret på Ricœurs kritiske hermeneutik. Studiets kompleksitet med at indfange fysiske, psykologiske og sociokulturelle ændringer hos kvalificeret hospitalspersonale blev bygget på flere teoretiske rammer inden for kvalitet af pleje og behandling, didaktik og transfer. Etnografisk feltarbejde blev anvendt til at undersøge personalets

overførsel af menneskelige færdigheder. En hybrid analytisk metode (RI-CEA) blev udviklet for at udforske, hvordan transfer indtraf. RI-CEA omfattede en Ricœur-inspireret analytisk tilgang og Cognitive Event Analysis, hvilket muliggjorde både et 1. og 3. persons perspektiv på data.

De etnografiske data blev indsamlet mellem februar 2019 og februar 2020 og omfattede cirka 107 timers videooptagelser, feltnoter og skriftlige refleksioner.

Resultater: Den systematiske gennemgang fremhævede behovet for at genoverveje fokus på transfer af menneskelige færdigheder. Adskillige vurderingsværktøjer er blevet udviklet for at gøre menneskelige færdigheder synlige til justering, under og umiddelbart efter simulationsbaseret træning. Den systematiske gennemgang fastslog effektiviteten af træning i menneskelige færdigheder hos kvalificeret hospitalspersonale, men udfordringer med at vurdere udviklingen af menneskelige færdigheder hindrer sammenligninger af effektivitet. Opfattelsen af menneskelige faktor færdigheder som medfødte og vanskelige at træne persistere, hvilket udgør en potentiel hindring for overgangen af menneskelige faktor færdigheder fra simulationsbaseret træning til kompetence. Denne konklusion tjente som en grundlæggende forståelse for den efterfølgende etnografiske undersøgelse.

Den etnografiske undersøgelse omfattede tre faser: Klinisk fase (før), Simulationsbaseret træningsfase (under) og Transferfase (efter). Den naïve læsning af data fra den kliniske fase afslørede en meget omskiftelig klinisk praksis. De analytiske temaer koordination, afbrydelser, uddannelsesansvar, teamwork og situationsbevidsthed blev integreret i træningsforløbet i den følgende fase. Den simulationsbaseret træningsfase understregede vigtigheden af træning. Deltagerne udtrykte fokus på tekniske færdigheder, men manglede focus på eller træning af menneskelige færdigheder i hverdagen. Den strukturelle analyse identificerede temaerne uddannelsesansvar, feedback, beslutningstagning, lederskab og teamwork, der formede fokus i den efterfølgende Transferfase. Transferfasen afslørede engageret kvalificeret hospitalspersonale, der var åbne for træning i menneskelige færdigheder og understregede positiv interesse. Dog inkluderede udfordringerne manglen på et sprog omkring menneskelige færdigheder, manglende tid og et dilemma mellem ønsket om at forbedre de menneskelige færdigheder og oplevelsen af manglende prioritet blandt kolleger og organisationer.

Analysen afdækkede tre nøgleniveauer: Individuel, Interkollegial og Organisatorisk transfer af læring. Disse sammenkoblede og afhængige niveauer kastede lys over den begrænsede transfer af menneskelige færdigheder efter simulationsbaseret træning. Resultaterne antydede, at erhvervelsen af menneskelige færdigheder fandt sted på både det individuelle og det interkollegiale niveau. Imidlertid var der behov for øget organisatorisk opmærksomhed og støtte for at sikre, at viden blev transferreret til kompetence i klinisk praksis. Insufficient opmærksomhed og støtte til transferprocessen, internalisering og fastholdelse af de menneskelige færdigheder på organisationsniveau bidrog til disse mangler.

Implikationer: Denne afhandling udforskede den undersøgte transferproces af menneskelige færdigheder fra simulationsbaseret træning til kompetence i klinisk praksis. Resultaterne antydede behovet for en bredere træningsfokus, involvering af lokale ambassadører for menneskelige færdigheder og koordineret planlægning mellem simulationscentre og organisationer for at optimere overførslen af menneskelige færdigheder og forbedre patientsikkerheden. Forskningen identificerede områder til yderligere udforskning, herunder udvikling af en generisk transferstrategi, vurdering af dens indvirkning på kompetence og undersøgelse af forholdet mellem sundhedspersonales kompetence inden for menneskelige færdigheder og patientsikkerhed.

List of Supervisors and Opponents

Supervisors

Lise Hounsgaard, professor, PhD, MSc Nursing, RN (primary supervisor)
Open Patient data Explorative Network, Odense University Hospital/Department of Clinical Research, University of Southern Denmark, Odense, Denmark
Institute of Nursing & Health Science, Ilisimartusarfik, University of Greenland.

Sune Vork Steffensen, professor, PhD
Centre for Human Interactivity, Department of Language and Communication, University of Southern Denmark, Odense, Denmark
Centre for Research in Patient Communication, Odense University Hospital, Odense, Denmark & Danish Institute for Advanced Study, University of Southern Denmark, Odense, Denmark
Center for Ecolinguistics, South China Agricultural University, Guangzhou, China
College of International Studies, Southwest University, Chongqing, China

Palle Toft, professor, PhD, MD
Anesthesiology and Intensive Care Department, Odense University Hospital, Odense, Denmark
Department of Clinical Research, University of Southern Denmark, Odense, Denmark

Christian Backer Mogensen, professor, PhD, MD
Emergency Research Department, Hospital Sønderjylland, University Hospital of Southern Denmark, Odense, Denmark

Assessment Committee

Hanne Agerskov, professor, PhD, MSc Nursing, RN (Chair)
Department of Nephrology, Department of Clinical Research, University of Southern Denmark

Mary Lavelle, Senior lecturer, PhD, Psychologist
Psychologist School of Psychology, Queens's University Belfast, Northern Ireland

Mette Spliid Ludvigsen, professor, PhD, MSc Nursing, RN
Faculty of Nursing and Health Sciences, Nord University, Norway
Randers Regional Hospital, Clinical Research Unit, Denmark
Health/Department of Clinical Medicine, Aarhus University, Denmark

Disclosures and Funding

This study has been funded by:

- Anaesthesiology and Intensive Care Department, Odense University Hospital, Denmark.
- Department of Clinical Research, University of Southern Denmark, Denmark.
- Hospital Sønderjylland, Aabenraa, Denmark.
- Centre for Research in Patient Communication & Human Skills, Clinical Development, Odense University Hospital, Denmark.

We are what we repeatedly do –
Excellence, then, is not an act but a habit.

Aristotle *(Durant et al., 1927)*

Abbreviations, Key Definitions and Terminology

Abbreviations

An overview of the abbreviations that will be used throughout this thesis.

Abbreviation	Meaning
ABCDE	**A**irway, **B**reathing, **C**irculation, **D**isability, **E**xposure
ANTS	**A**naesthetists' **N**on-**T**echnical **S**kills
ATLS	**A**dvanced **T**rauma **L**ife **S**upport
CEA	**C**ognitive **E**vent **A**nalysis
CPD	**C**ontinuing **P**rofessional **E**ducation
CPR	**C**ardio**P**ulmonary **R**esuscitation
EPALS	**E**uropean **P**aediatric **A**dvanced **L**ife **S**upport
HFS	**H**uman **F**actor **S**kills
IPE	**I**nter**P**rofessional **E**ducation
RIA	**R**icœur **I**nspired **A**nalytical Approach
RI-CEA	The hybrid method of a **R**icœur **I**nspired Analytical approach and **C**ognitive **E**vent **A**nalysis
SBAR	**S**ituation, **B**ackground, **A**nalysis, **R**ecommendations - in Denmark, it is ISBAR (**I**dentification)
SBT	**S**imulation-**B**ased **T**raining
QHP	**Q**ualified in-hospital **H**ealthcare **P**ersonnel

Definitions of key concepts

A short overview and definition of the thesis' key concepts. These definitions are superior, contain particularities, and will, therefore, be elaborated upon in **Chapter 5, Theoretical Framework**.

Concept	Definition
Adult learning	Adult learning is formal and informal education and training activities undertaken by adults after leaving initial education and training. It focuses on adult learners' unique needs, emphasising clear goals, meaningful experiences, self-direction and collaboration between teachers and adult students, a learner-centred approach, and adapting to their everyday clinical practice (Merriam, 2017).
Adverse events	An adverse event is 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 not due to the patient's illness but either harmful or could have been harmful (near-accident) (Abildgren et al., 2022).

Competency	Competency is a skill developed based on knowledge, experiences and behaviour towards qualified activities that can be put into action in everyday practice. Competency demands intentional and directed actions, individual, personal and replicating. This definition is inspired by the Danish pedagogic term action competencies (Jensen and Schnack, 1997).
Human factor skills	Human factor skills encompass cognitive, social, and behavioural abilities that individuals use to interact effectively in complex systems. These skills include decision-making, communication, teamwork, and adaptability, which are crucial for enhancing performance and safety in various environments and emphasise how the environment, the organisation and human psychology interact (Russ et al., 2013).
Patient safety	Patient safety is preventing, reducing, or mitigating harm to patients during medical care, ensuring their well-being and minimising the risk of medical errors, infections, and other adverse events in healthcare settings.
Simulation-based training	Simulation-based training is a technique for training competencies with authentic experiences guided by imitating real-world situations. Through scenarios with specific learning objectives, participants have hands-on learning experiences, enhancing skills and knowledge in a safe and controlled environment (Rosen, 2008).
Transfer	Transfer of learning refers to applying knowledge and skills acquired in one context to another, enabling learners to adapt and utilise their learning effectively in different, relevant situations, fostering profound understanding and problem-solving capabilities (Dohn and Hachmann, 2020).

Terminology

An overview of the thesis terminology.

Term	Sense
Continuing Professional Development	Continuing Professional Development is an ongoing learning process that helps individuals in various fields, especially professionals, maintain and enhance their knowledge and skills throughout their careers. It involves workshops, courses, and self-directed learning to stay updated and improve performance.
Facilitators	A facilitator is a simulation-based education expert with at least a 3-day facilitator course who guides learners through simulated training experiences. They coordinate scenarios, provide guidance, and foster a realistic learning environment, helping participants acquire practical skills and knowledge. Further, they conduct the learning-based debriefing after the simulation. Most facilitators in healthcare are qualified healthcare

	personnel with simulation-based education as an application to their medical jobs. They are used ad hoc in the wards and simulation centres to train other QHP.
Healthcare team	A healthcare team is a diverse temporary group of professionals assembled ad hoc to address a specific patient or medical situation. It is formed as needed for immediate, collaborative care and often disbands once the task is completed. It includes, e.g. doctors, nurses, therapists, and support personnel working collaboratively to provide comprehensive medical care, promote patient well-being, and address physical and emotional health needs.
Interprofessional Education	Interprofessional education is an approach to collaborative learning in which participants from different healthcare disciplines work together to improve their understanding of each other's roles and enhance teamwork skills. It promotes effective, patient-centred care by fostering interdisciplinary collaboration (Thistlethwaite, 2012).
Organisation	An organisation is a structured group of people with common goals and objectives, working together to achieve a specific purpose. It typically has a defined hierarchy, roles, and processes to facilitate efficient operation and decision-making.
Participants	Participants engage in the ethnographic study and participate in various activities, interventions or talks. They play an active role, contributing their involvement, insights, and contributions to answer the research question.
Qualified in-hospital Healthcare personnel	Qualified healthcare personnel are skilled and certified professionals, such as doctors, nurses, physiotherapists and assistant nurses, who possess the necessary knowledge, training, and competence to provide patients with safe, effective, and compassionate medical care. Their competence level is labelled according to the Dreyfus model's five stages, from novice to expert (Dreyfus and Dreyfus, 1980).

SimLEARN - a Research Collaboration

This thesis is part of the SimLEARN research project, a cross-faculty and cross-institutional research collaboration of two PhD studies. The overall purpose of SimLEARN was to investigate if and how simulation-based training of human factor skills can reduce adverse events by studying the phenomenon through a social science perspective on medicine handling and a health science perspective on teamwork. The hypothesis was that the two scientific perspectives on this complex problem could enlarge and deepen the outcomes. This thesis was situated in health science and the clinical health faculty; the other part of the twin PhD study by Malte Lebahn-Hadidi was situated in social science and the humanities faculty.

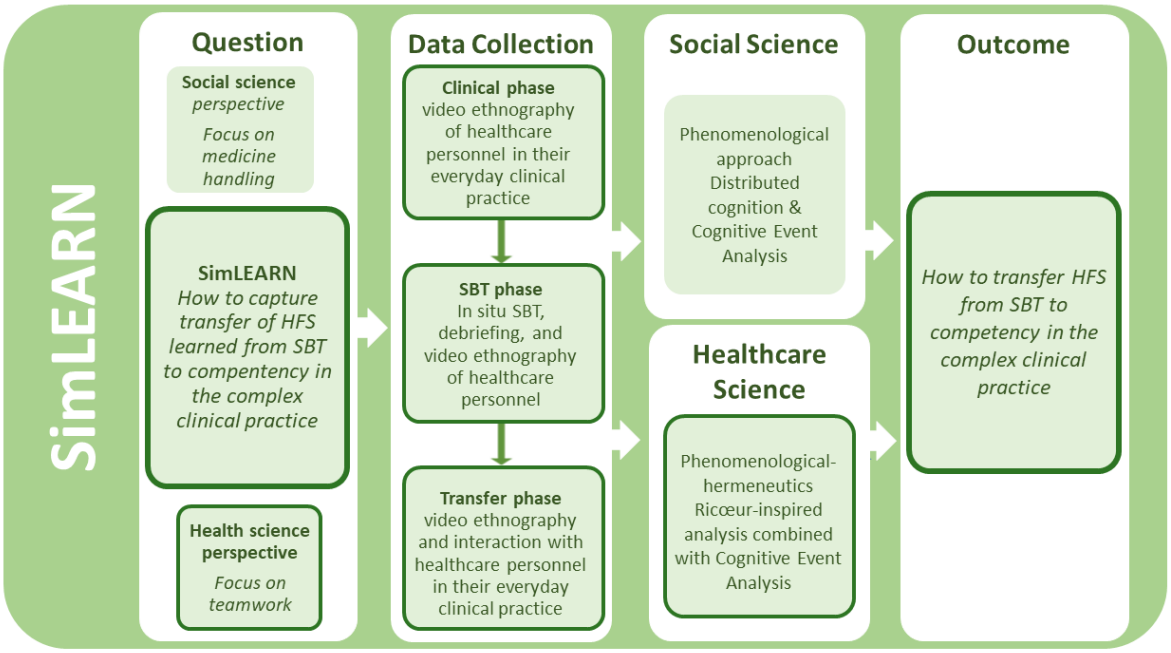
Picture 1: The two PhD students in a critical care room during the SBT course and the high-fidelity patient simulator.

SimLEARN the history

The SimLEARN collaboration was created at the beginning of 2017 after a joint brainstorming session during a meeting with the future research group. The project was developed in collaboration from ideas to hypothesis, the overall research question, how this research question could be investigated, and finally, the study design's development. Further, a joined gathering of the empirical data, continuous discussions and spares about wonders, problems, and findings are performed. The research group's cross-scientific constellation and back-and-forth discussions have profited the project. Lebahn-Hadidi's communicational and social science expertise and Abildgren's clinical healthcare, simulation-based training and educational expertise expanded the understanding and insights into the research data, analysis and conclusions. The findings are reported in co-authored articles.

It is essential to point out that although the two PhD studies complement each other and have had an extensive collaboration, this thesis is an individual work that has gained an extended and in-depth analysis and findings through the partnership. SimLEARN's project design is visualised in Figure 1. The path of this PhD study is marked with a thick green contour. Lebahn-Hadidi's anthological PhD was defended successfully in 2022 (Lebahn-Hadidi, 2021).

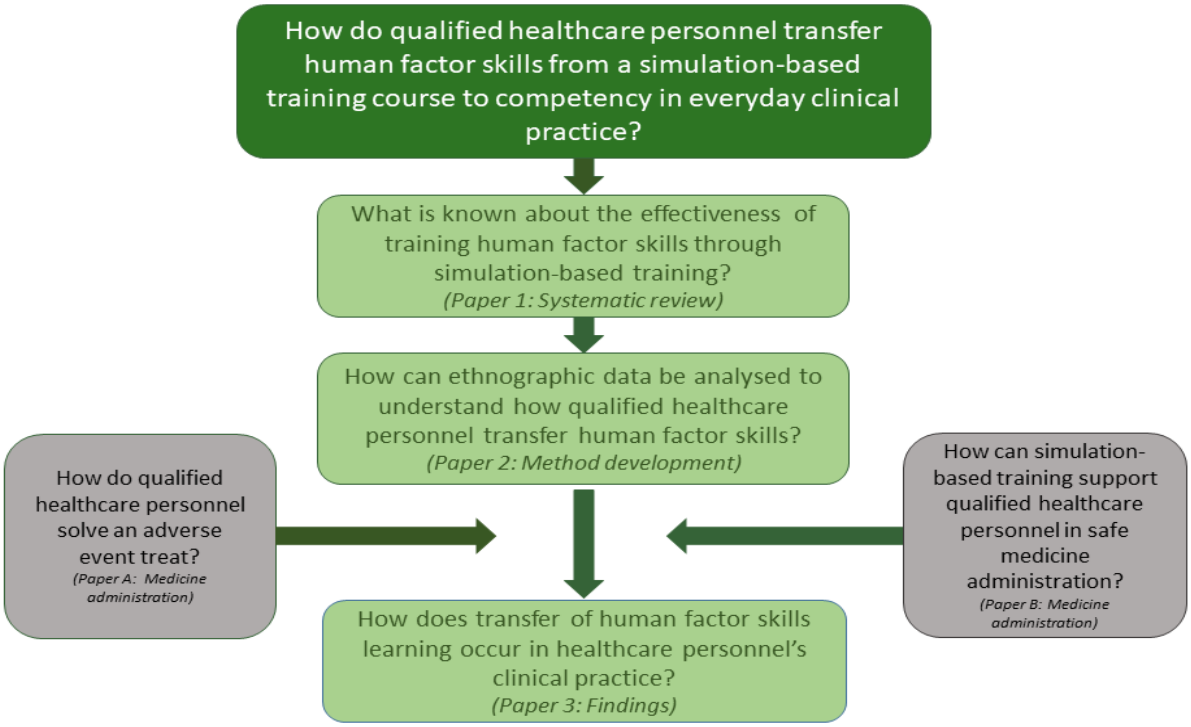
Figure 1: SimLEARN Project Design.



Papers

Abildgren is the primary author in papers I-III and the secondary author in papers A and B. Lebahn-Hadidi is the secondary author in papers I-III and the primary author in papers A and B. The two studies also share supervisors. Professor Lise Hounsgaard (Health Science, University of Southern Denmark) is the primary supervisor of this study, with Professor Sune Vork Steffensen (Social Science, University of Southern Denmark) being the secondary supervisor, and vice versa in Lebahn-Hadidi's project. Moreover, clinical professor Palle Toft and clinical professor Christian Backer Mogensen, respectively, from Odense University Hospital and Sygehus Sønderjylland, are co-supervisors in this study, showing the cross-institutional nature of the project. Figure 2 maps the papers and the substudies' research focus.

Figure 2: Map of the study flow and focus of the research questions.



Structure of this Thesis

The following section provides an overview of the thesis and a reading guide.

The **Chapter Abbreviations, Key Definitions and Terminology,** placed before the Preface and Introduction, can be used as a quick guide throughout the reading (p. 1-3). The chapter outlines the thesis' abbreviations, markers, key concepts and terminology. The introduction in **Chapter 1 - Introduction** provides the reader with the research area of patient safety and continuing professional development (also called lifelong learning). The theoretical background and motivation of the study behind this thesis are presented in **Chapter 2 - Background**, showing the gap between what is known and what is unknown in transferring human factor skills into competency in clinical practice after simulation-based training. The theoretical background leads to **Chapter 3 - Aim and Research Question**, which presents the study's overall aim and research questions, along with the sub-studies within this study. Each substudies' aim and research questions of how they support the overall research question are presented and visualised. **Chapter 4 - Scientific Framework** describes the study's epistemological foundation and the multifaceted scientific framework. The study's theoretical framework consists of three key concepts: Quality of care, didactics, and transfer, which are elaborated to support the choices made about and within the data collection and intervention. The methods and methodologies of the systematic review and the ethnography are introduced in **Chapter 5 - Methods and Study Design**. Further, the chapter presents the study design and simulation-based training intervention, followed by a

presentation of the developed hybrid interpretation method. Finally, the chapter presents the ethical considerations of the study. The findings are presented in **Chapter 6 - Findings**. **Chapter 7 - Discussion** discusses the study's findings and methodological considerations, validity, reliability and transferability.

Chapter 8 - Conclusion, concludes this thesis' research question. Lastly, the implications for practice and future perspectives are presented in **Chapter 9 - Implications for Practice and Perspectives**.

1. Introduction

This thesis deals with the importance of a qualified use of human factor skills in healthcare, the impact of human factor skills on patient safety, and how qualified healthcare personnel can improve their human factor skills to benefit the patient and relatives in their care. Through an ethnographic investigation and interpretation, I developed knowledge on how **qualified in-hospital healthcare personnel** (QHP) transfer **human factor skills** (HFS) taught in an **in situ simulation-based training** (SBT) course to competency in everyday clinical practice. QHP's actions, interactivity and behaviour, are studied before, during and after the intervention of an SBT course.

This PhD project includes three studies:

- The study of the effectiveness of training qualified healthcare personnel's human factor skills through simulation-based training
- The study of how to analyse ethnographical data to identify qualified healthcare personnel's transfer process of human factor skills from simulation-based training to competency in clinical practice.
- The study of how qualified healthcare personnel transfer human factor skills from in situ simulation-based training to complex clinical everyday.

The patient safety issue in healthcare

Patient safety might be among today's most crucial healthcare issues. Society's focus on patient safety has emerged and progressed in the last three decades with the evolving complexity of healthcare. In 2019, patient safety became one of WHO's global health priorities (World Health Assembly, 2019). Globally, patient safety organisations aim to prevent and reduce risks, errors and harm (adverse events) to patients during healthcare delivery. The approach to patient safety has evolved from the goal of eliminating all errors and adverse events, an approach called Safety-I, to the purpose of learning from errors and adverse events and improving the practice, deemed Safety-II (Hollnagel, 2015, MacKinnon et al., 2021). The core of learning from adverse events is to transform the error into learning objectives that can impact all organisational levels, from individual to national or international guidelines to prevent future adverse events; for instance, recurring CPR training of QHP to increase cardiac arrest survival.

Adverse events are a global phenomenon that can increase morbidity, mortality, prolonged hospital stay, and healthcare costs (Kohn et al., 2000, Lapointe-Shaw and Bell, 2019). Countries have different ways and cultures of registering and managing healthcare errors, adverse events, and harm. In some countries, QHP has a personal and economic responsibility in case of adverse events; in others, they can lose their licenses to practice. In contrast to such an approach, the Danish healthcare system takes a systemic stance towards adverse events, focusing on learning from errors, where individuals (QHP) are indemnified of their adverse events. Still, repeating errors, harm, neglect of learning, and negligence can lead to personal responsibility and loss of

license to practice (Patientsikkerhed, 2023c, Patientsikkerhed, 2023a). Denmark's patient safety system is built on assumptions of trust and anonymous self-reporting through a nationwide IT system, e.g. the National Patient Safety Organisation and the local healthcare institutions analyse and process adverse events to make organisational efforts consisting of learning and changes in the organisational systems.

Prevention of Adverse Events

The number of reported adverse events has stabilised after increasing throughout the last 20 years of registration in Danish hospitals rather than decreasing as wanted and expected (Center for Kvalitet, 2015). In 2022, 48,853 reports were made in Danish hospitals. 484 was categorised as severe or deadly within information delivery, visitation, admission or discharge, depending on HFS (Patientsikkerhed, 2023b). Analyses of adverse events show that more than 50% could be prevented (Kang et al., 2022, Panagioti et al., 2019). Estimates show that most preventable adverse events can be traced back to a breakdown in QHP's HFS (Aaberg et al., 2021, Uramatsu et al., 2017). These results suggest that although there is a focus on learning from errors, it does not change the QHP clinical practice or behaviour as desired. It is known that cognitive, social and psychological skills influence the transfer from knowing to doing (Dohn et al., 2020). Implementing new procedures is more complex than adding information and training algorithms.

Adverse events also have economic and human impacts on healthcare. The estimated cost burden of preventable adverse events on the healthcare systems in OECD member countries is $878 billion (2018) (Slawomirski, 2020). Adverse events affect not only the patient and relatives (first victim) or the economy but also the QHP (second victim) who are involved in adverse events (Schrøder et al., 2022). Research shows that cognitive bias, communication breakdown, ineffective teamwork, fatigue, blame and burnout are some problems QHP experiences as the cause or effect of adverse events (World Health Organization, 2023a).

Pre-Understanding

At the beginning of this project, my understanding of patient safety and learning from errors was shaped by 20 years as a nurse in clinical practice, eighteen years within critical care, and ten years of work with SBT and other types of facilitating, instructing and teaching. As a nurse and a teacher, I was embedded in a biomedical system mainly focused on results and evidence-based practice rooted in positivism and empiricism. Contrary to such a scientific method, I considered nursing an interactional practice, as presented by Merry Scheel (Scheel et al., 2008), where nursing is viewed as a science within a dynamic field between natural, human and social sciences, enabling the explanation and interpretation of complex health interventions. I, therefore, regarded the human as a being consisting of natural, human and social essentials and needs, including culture, and when investigated, also ought to include a multi-sided line of thinking and scientific approaches.

I regarded performance and day-to-day operation as the organisational way of managing the healthcare system, focused on economic terms and results of RCT studies as "*the right way*" of

evidence-based practice. My work focused on interactions, behaviour and the use of HFS, and it was challenging and even more difficult to show a direct effect between training and patient safety. HFS are not captured in numbers and p-values, and it is difficult to measure outcome, the impact of training HFS should be seen in a broader perspective bio-social-psychological.

2. Background

From an overview of patient safety and adverse events, this chapter narrows the focus to the learning approach to patient safety. It describes this study's rationale and scientific foundation.

From adverse events to patient safety

The Danish Patient Safety system is based mainly upon the Safety-II principles perspective (Patientsikkerhed, 2016, Patientsikkerhed, 2021), focusing on avoiding future errors – individual and organisational. Until now, interventions to learn from errors have primarily focused on providing knowledge, often through guidelines and newsletters. However, in recent years, SBT has also been used to train highly acute and life-threatening situations to reduce adverse events (MacKinnon et al., 2021, Juelsgaard et al., 2022, Cory et al., 2020, Hazwani et al., 2020, Arora et al., 2014, Weile et al., 2021, Fransen et al., 2020).

Despite organisational efforts and continual education of QHP, adverse events reappear in clinical practice, underpinning that the teaching and learning approaches could be increasingly effective or different. Trying to change this, the Danish Patient Safety Authority and healthcare institutions produce and introduce more and more information, recommendations, instructions, guidelines (i.e., CPR, sepsis, trauma), mnemonics (i.e., ABCDE, SBAR), and SBT of these. Despite the efforts, the number and types of adverse events are almost status quo, with the reappearance of repeated adverse events (Patientsikkerhed, 2023b, Danish Patient Safety Authority, 2017). The present approach to establishing learning from adverse events does presumably not change the QHP's way of working in clinical practice. This could suggest that the formula for reducing adverse events has yet to be found. One perspective could be that transfer of new knowledge to competency in clinical practice fails. Another is that the focus on knowledge transfer to competency needs to be improved.

Education of healthcare personnel

In Denmark, there is an extensive focus on lifelong learning, also called **Continuing Professional Development** (CPD), in all areas of the workforce. In Denmark, CPD mainly focuses on individual learning and technical skills (Kompetence Sekretariatet, 2013, Danmarks Evalueringsinstitut, 2011, Jørgensen, 2007).

Hospital managers and faculty continuously focus on QHP's professional development of necessary skills to monitor, diagnose, treat, inform, comfort, and care for patients and relatives. The educational initiatives are often chosen from an organisational point of view based on collected data: what should be taught and trained, and which areas require awareness to increase patient safety or qualify new personnel. Data are gathered from diverse sources like statistics, adverse events and patient complaints (Morsø et al., 2022) or tangible subjects (e.g. laparoscopy, peripheral venue catheter and airway management). The effort to increase and update QHP's knowledge is primarily theoretical teaching, guidelines, or newsletters to address specific

problems (Danish Patient Safety Authority, 2017). This way of teaching is generally low-cost and a way to reach the QHP quickly. Knowledge differs from changing behaviour or turning newly acquired skills into competency. Additionally, the high turnover and lack of QHP in healthcare make it challenging to maintain a high level of competency in a ward. For instance, the turnover of Danish full-time nurses (~150,000 DKK/nurse in 2021) costs 1.2 billion DKK (~162 million Euro) every year (Tram, 2021). Maybe if new personnel attended mandatory courses, the integration of the personnel into speciality, work teams, and culture could be reached, and the turnover costs could be reduced.

Segmented education of healthcare personnel

Curing patients requires an interprofessional setting with different specialities and educational backgrounds: doctors, nurses, nurse assistants, and physiotherapists, among others. Nonetheless, CPD in healthcare is often undertaken in silos, as the metaphor often goes – doctors with doctors, nurses with nurses, etc. – among pregraduates as well as QHP (Margalit et al., 2009, Gupta and Arora, 2015). The silo educational approach implies that learning each QHP profession's competencies, strengths, and specialities is implicit in working together. Clinical practice needs collaboration and the use of different educational competencies. HFS is comprised of collaboration and becomes the glue that combines other specialities, competencies, and educational strengths to cure the patient. As mentioned above, more than 50% of adverse events in healthcare can lead back to a breakdown in HFS; to increase patient safety in healthcare, hypothetically, the focus on improving QHP's HFS should intensify.

The effectiveness of training human factor skills

A scientific consensus on the positive effects of simulation-based education on technical skills has emerged (Rewers and Østergaard, 2021, Hazwani et al., 2020, Gjeraa et al., 2014); however, there is still a requisite for knowledge of the effectiveness of training HFS and how QHP transfers skills taught and trained in SBT to competency in clinical practice. Before industrialisation and technological expansion, the demand for adaptation to novel challenges was less; you learned new skills through apprenticeship, and when you were fully qualified, you learned the rest through experience (Centeno, 2011, Bagnall, 2009). Today, the challenge is the rapid changes and high complexity in healthcare technology, treatments, patient care, organisational frames, a high personnel turnover and a worldwide lack of QHP. This induces a constant demand to add knowledge, develop and upgrade qualifications and competencies, train QHP and transfer these competencies and qualifications into enactivity in everyday practice (Brigley et al., 1997, Goldman et al., 2009, Kumar et al., 2021).

Research shows that SBT can develop and improve technical skills and transfer these to competency in clinical practice, where the participants become more highly skilled earlier than participants without an SBT course (Andersen et al., 2015, Gustafsson et al., 2019, Nielsen, 2023). However, whether SBT can improve HFS and to what extent remains to be discovered.

A systematic review of the effectiveness of simulation-based training to improve human factor skills

In the following section, the main results from Paper I are presented; thus, the paper presents an overview of the existing literature within the area of the effectiveness of improving in-hospital healthcare teams' HFS using SBT as a learning and teaching method (Abildgren et al., 2022).

The results of this sub-study argue for the necessity for supplementary research, support and development of awareness, and focus on an SBT intervention. The main results from Paper I indicate that SBT improves QHP's HFS. Yet, the results show dilemmas due to a minimal focus on transfer and retention of skills. The study presents an overview of existing literature within the area, which argues for the necessity of developing knowledge about transfer of knowledge from SBT to competency in clinical practice and informs the subsequent ethnographic study. Seventy-two peer-reviewed studies were included. Paper I presents a literature matrix of the included studies (Paper I, Table 3, pp 6-10).

The findings show that clinical practice increasingly uses SBT to train QHPs' HFS. Conversely, there is a lack of knowledge about how QHP transfers knowledge and behaviour from SBT to competency in everyday clinical practice. Moreover, the focus in SBT of QHP is, as mentioned above, mainly on highly acute, critical situations and settings, and training in standardised acronym courses and the HFS is often a secondary focus (an add-on) to the medical and technical skills. The reasons could be that HFS are not easily grasped and interpreted. The systematic review's multiple uses of assessment methods (51 different in 72 studies) underpins that. The vast differences between the included study methods, designs and assessments made it challenging to compare the studies. Therefore, the conclusion is only a tendency of effectiveness in improving HFS.

When interpersonal skills are trained using SBT, the focus is typically on training broad terms such as communication and teamwork in highly acute situations like trauma, postpartum bleeding and resuscitation, using algorithms and acronym courses (e.g. ATLS, EPALS, SBAR, ABCDE principles). This approach transforms the HFS into a technical algorithm, and the medical knowledge, diagnoses, treatments and technical use of the algorithms steal the focus from the HFS training, maybe due to the eagerness to monitor the new knowledge through the positivistic scientific paradigm. This approach is challenging; on the one hand, QHP needs routines and systematic approaches to care for the acute critically ill patient; on the other hand, they need an understanding of how HFS impact all their everyday clinical situations. Acute and critical situations are only a minor part of the daily clinical practice; however, they vary due to the speciality; therefore, it is interesting why acute situations are prioritised in SBT above the daily routines. A reason could be that QHP lacks competencies of HFS, which becomes very visible in acute critical situations.

Simulation-based training of HFS was mainly an add-on to SBT of technical skills (e.g. shoulder dystocia, CPR, and anaphylaxis). Findings showed that courses focused solely on HFS had higher

effectiveness than courses with HFS as an add-on to technical skills. This indicates that technical skills often poach the focus away from HFS because technical skills are more accessible to assess than HFS. The heavy load of research on new HFS assessment tools supports this interpretation. Further, HFS is often tied to individual and group culture; culture changes are slow and involve reinforcement of teaching and training.

The systematic review underlines that HFS are not innate; it is knowledge you can enact, like technical skills. HFS can be trained and developed. Nevertheless, research shows that knowledge add-ons only sometimes lead to new competencies in everyday practice. Knowing is not the same as doing. Speaking is not the same as externalising thoughts. QHP are living organisms comprehending as they act and vice versa. The systematic review supports the strong belief that SBT can teach and improve QHP's HFS and consequently improve patient safety, but it is not evident. The systematic review concludes that SBT is an effective method to teach HFS to QHP. Still, there is a lack of knowledge on how QHP transfer HFS from SBT to competency in clinical practice, retention of the HFS and the impact of improved HFS on patient safety.

Transfer to Competency

In recent years, research in transfer has expanded, yet the research often focuses on transfer of knowledge, technical skills, and some cognitive skills in fixed laboratory research (Healy and Wohldmann, 2012, Burke and Hutchins, 2007, Youssef-Shalala et al., 2014). Moreover, the transfer research concentrates mainly on individual behaviour and the combination of behaviour, knowledge and interactions. In healthcare, QHP often works in teams and depends on the other team members' performance, decisions, task management, and situation awareness. Additionally, good HFS allow QHP to concentrate extra on the technical side of the task (Sollid et al., 2019). Therefore, a demand exists for supplementary knowledge on how transfer of HFS becomes competency in everyday teamwork in healthcare.

It is known with growing certainty that adverse events often can be traced back to a collapse in HFS, e.g. communication, situation awareness and teamwork, that SBT is increasingly used to train QHP and that SBT can improve QHP's HFS. It is assumed that QHPs' segmented education impacts their HFS in teamwork, that QHP wants to deliver high-quality care for the patient, and that patient safety can be improved with suitable HFS. Based on these assumptions, it is evident that there is a breach between the QHPs' training and learning and their competency in clinical practice. Therefore, there is a need to investigate how QHP's newly taught and trained HFS is transferred into competency in everyday clinical practice. This PhD study investigates QHP's HFS competency in their clinical settings before, during and after participating in an in situ SBT course.

3. Aim and Research Questions

This PhD study aimed to develop new knowledge about how QHP transfers HFS to competency in daily clinical practice. This knowledge might contribute to understanding how to increase QHPs' transfer of HFS to competency towards a safer healthcare environment for the patient. The aim was investigated from the following overall research question:

***How do qualified healthcare personnel transfer human factors skills taught and trained in an in situ simulation-based training to competency in everyday clinical practice*?**

A qualitative investigation of the transfer phenomenon focused on how the QHP and their clinical environment understand, perceive, and approach transfer, how transfer is observed and embodied in the QHPs' HFS, and possible behaviour changes. Due to the complex nature of investigating transfer of HFS to competency in clinical practice, the research question integrates diverse theoretical frameworks such as patient safety, didactics, and transfer, as elaborated in Chapter 4.

Overview of the Substudies

This PhD study consists of five substudies, with different research questions and aims accomplished in a research fellowship of two parallel running PhDs, but with different sub-studies and thesis. In the PhD period, I conducted the studies marked with a number (1-3) and contributed data, ideas, spares, and discussions in the studies marked with a letter (A-B). These studies (A-B) are parts of the SimLEARN partner's PhD thesis - the co-author statement is provided in Appendix 1.

The substudies research questions are:

Study 1: What is known about the effectiveness of training HFS through SBT? (Paper I)

Study 2: How can QHP's transfer of HFS to competency in clinical practice be detected in ethnographical data? (Paper II)

Study 3: How does QHP transfer HFS from in situ SBT to competency in complex clinical everyday? (Paper III)

Study A: How does QHP solve an adverse event threat? (Paper A)

Study B: How can SBT support QHP in safe medicine administration? (Paper B)

All in all, this PhD study aims to develop knowledge of how QHP transfers HFS trained through SBT to competency in clinical practice from a health science perspective. An overview of the substudies from Table 1 clarifies their distinct aims, methods, data, and analytical approach. The overall study design contains three levels: a theoretical level, a methodological level and an interpretation level.

Table 1: Overview of the substudies according to research questions, aims, methods, data included and analytical approach.

	Systematic review	Developing a method	Ethnography	Substudy A	Substudy B
Research question	What is known about the effectiveness of training HFS through SBT?	How can QHP's transfer of HFS to competency in clinical practice be detected in ethnographical data?	How does QHP transfer HFS from in situ SBT to competency in complex clinical everyday?	How does QHP solve an adverse event threat?	How can SBT support QHP in safe medicine administration?
Aim	The aim is to investigate the effectiveness of simulation-based training in improving in-hospital QHP's HFS.	The aim is to develop a method that contributes to understanding how the QHP transfers HFS from SBT to competency in everyday clinical practice.	The aim is to understand how QHP transfers human factor skills from an in situ simulation-based training course to competency in complex everyday clinical practice.	The aim is to understand what happens during an adverse event threat and how the QHP copes with this threat.	The aim is to shed light on the interaction between two safety logics of collaboration and non-interruption in a medical room
Methods	Systematic Review		Ethnography	Cognitive Ethnography	Cognitive Ethnography
Data	72 peer-reviewed studies		107 hours of videorecordings, fieldnotes	107 hours of videorecordings, fieldnotes	107 hours of videorecordings, fieldnotes
Analytical approach	Thematic analysis		Ricoeur-inspired approach & Cognitive Event Analysis	Cognitive Event Analysis	Cognitive Event Analysis

The theoretical level focuses on the existing knowledge of the effectiveness of improving HFS through SBT, which is investigated through a systematic review (Paper I). The methodological level revolves around the thesis' data collection through ethnography and interpretation methods. The complexity of the research question implies the necessity of a method that can interpret human behaviour and possible changes in the QHP's embodiment. An ethnographic study of QHP's HFS before, during and after an SBT course is expected to capture relevant data and identify, understand, describe and explain the transformation of HFS to competency through these. A hybrid analytical method of a Ricœur-inspired Analysis Approach (RIA) and Cognitive Event Analysis was developed (Paper II). Within the interpretation level, an analysis of two specific adverse events around medical administration contributes to the interpretation in RI-CEA (Paper A and Paper B) before answering the overall research question (Paper III).

4. Scientific Framework

This chapter describes the scientific and theoretical approaches taken in the PhD project, followed by descriptions of the frameworks that constitute the theoretical foundations of the PhD project's knowledge development. The project's epistemology will be presented, and hereafter, the diverse theoretical frameworks, such as quality of care, didactics, and transfer.

The PhD study comprises a qualitative research design, as it pursues insight, understanding and development of knowledge of QHP's lived experiences, reflections, and visible and tacit changes in actions before, during and after an SBT course focusing on their HFS. The PhD study highlights the complex problem of capturing QHP's physical, psychological and sociocultural changes during and after gaining new knowledge. Developing this knowledge builds on several theoretical frameworks. These frameworks also build upon each other, interact with each other, and depend on each other.

Epistemology

The assumptions of phenomenological-hermeneutic and ethnographic fieldwork methodologically and theoretically permeate the study and, thus, impact each step in the research process.

The phenomenological-hermeneutic approach is inspired by the work of the French philosopher Paul Ricœur's critical hermeneutic, which originated based on apparently incompatible philosophical positions from Aristotle to Husserl, Gadamer and Popper. Ricœur's philosophy synthesises by drawing on A and B, getting C. Ricœur provides with his phenomenological-hermeneutic new ways of improving investigations of phenomenons (Ricoeur, 2002). The fusion between phenomenology and hermeneutics gains the descriptive phenomenological exploration of lived experiences in the human life world and the hermeneutic interpretation and understanding. Ricœur argues that the distanciation from the intention to an objectifying approach is essential to gain a deeper understanding of lived life. In addition, Ricœur contends that the interpretation should be seen as a process characterised by a constant movement between the past and the present, between the parts and the whole, where new recognition arises between the lines of the text (Ricoeur, 1976).

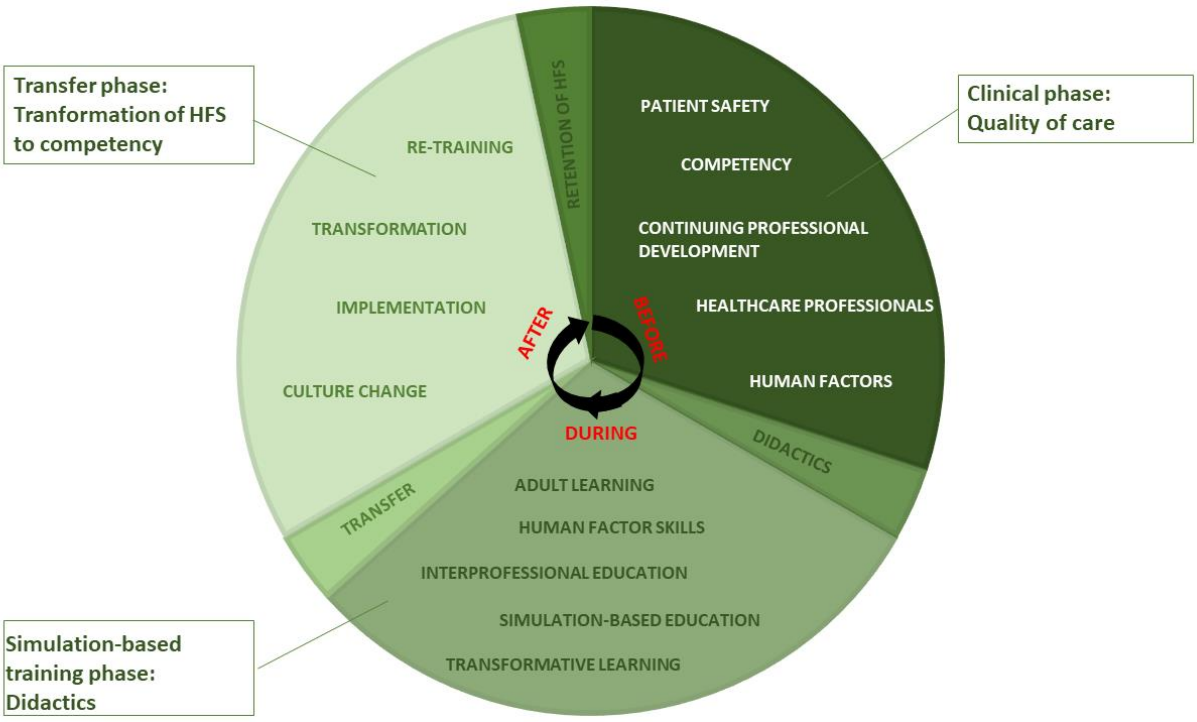
This epistemological approach requires the possibility of researching the transfer phenomenon as it develops through the participants' lived experiences, reaching a description of the phenomenon as it exists in the healthcare setting, and interpreting how transfer becomes competency in everyday clinical practice. Transfer to competency is not understood because it is an interactive, lived and contextual phenomenon. The phenomenological-hermeneutic approach enables the research of lived phenomenons that can not be measured or quantified and allows the researcher to focus on the parts and the whole. Further, Ricœur's suggest that it is a necessary distance between the phenomenon of interpretation and the interpreter. The distance allows for a kind of engagement that is neither too close nor too far, enabling a meaningful understanding of the text

(Ricoeur, 1976). The researcher's worldview (and culture) influences how the world is perceived and interpreted. Ricœur states that the argument is found between explaining and understanding, meaning that the analytical process provides the researcher with a better understanding of the researcher's own world when the pre-understanding is put into play by others' way of seeing the world and analysing this view. The researchers pre-understanding is then not locked but at stake, with a possible new understanding as a gain (Ricoeur, 1976).

Theoretical Framework

This PhD project's investigation of how QHP transfer HFS to competency is complex due to the underlying theoretical perspectives of the individual QHP, the healthcare organisation, and social, health and psychological scientific theories. These theories serve as the theoretical basis of the PhD project. Thus, the underlying philosophies impacted each step in the research process. For the benefit of this thesis, I have developed a model to describe how the theories are interrelated and interdependent (see Figure 3).

Figure 3: An overview and visualisation of the theoretical frameworks.



The theories are divided into three key concepts: 1) Quality of Care, 2) Didactics, and 3) Transfer, as these three key concepts correspond to the before, during and after phases of an SBT intervention. These categories serve as headings of a bundle of theories. Below is an elaboration of the three categories. Short definitions can be found in the Chapter Technicalities of the thesis, p. 1-3. The circle illustrates the continual process of assessing the quality of care in **the Clinical phase** (before), building upon patient safety issues, QHPs competencies and the necessity for CPD and human factors. Based on the evaluated quality of care, the process continues through didactic

decisions about how QHP should learn the needed competencies in **the SBT phase** (during). In planning an educational intervention (SBT), considerations about adult, transformative learning, and IPE are made before learning objectives (HFS) and methods (SBT, IPE) are chosen. Further, considerations of how the learning objectives (HFS) are transformed (transferred) into competency, including re-training, practice transformation, implementation, and culture changes before skills retention is attained in **the Transfer phase** (after). When the retention of the needed skills is obtained, the process restarts. The theoretical frameworks support the phases' content and help determine the choices for the next phase. The process is circular because its development always continues; a new assessment of the quality of care will propose new focus areas that should be addressed due to the never-ending evolution of healthcare and turnover.

Quality of Care

The quality of care in the clinical practice is assessed to gain knowledge of the QHP's needs for HFS learning and training. The current **quality of care** can be assessed in different ways. In this thesis, the quality of care covers patient safety, human factors, competency, and continuing professional development.

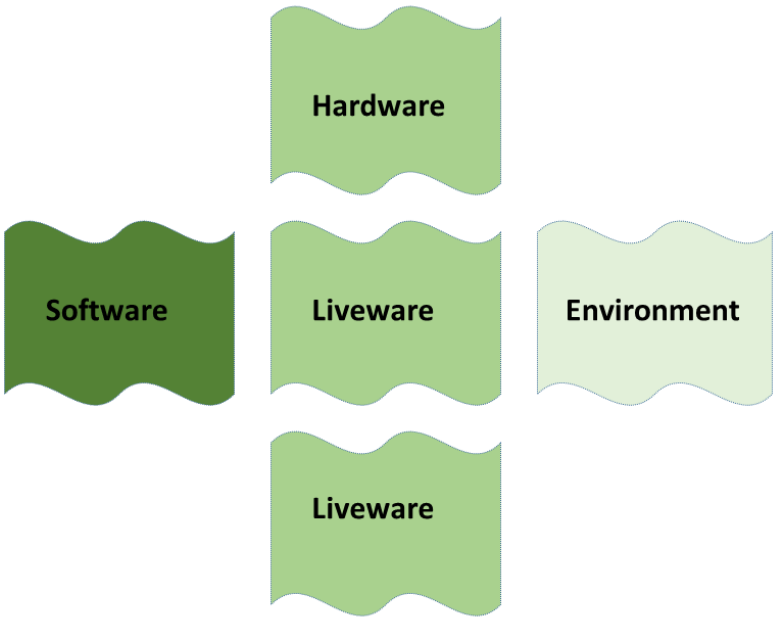
Quality of care has been characterised by many, for instance, researchers, politicians, WHO, etc. (Langford and Jain, 2023, World Health Organization, 2023b, Morsø et al., 2022, Indenrigs- og Sundhedsministeriet, 2023, Oldland et al., 2019, Rosen et al., 2018). In outline, they agree on the content, even though they differ in terms and numbers of characteristics. Oldland et al. (2019) highlight seven features in their framework of responsibilities in healthcare quality: 1) management of the environment, 2) promotion of safety, 3) evidence-based practice, 4) medical and technical competence, 5) person-centred care, 6) positive interpersonal behaviours and 7) clinical leadership and governance (Oldland et al., 2019, Molloy and O'Boyle, 2005). These characteristics are essential for any ward's quality assessment and educational intervention. Where are we, where do we want to be, and how do we get there? The organisation is responsible for creating settings, terms, opportunities and motivation for the QHP to attain these responsibilities. Four of the seven characteristics are especially important to this study's theoretical frame and will be elaborated on below.

Management of the environment covers elements of maintaining a healing physical space (e.g. décor, noise, equipment, comfort, privacy) for patients, relatives and QHP (Oldland et al., 2019). The environment is a keystone in patient safety work. In this thesis, the term ***human factors*** will be used to refer to the concept of management of the environment. Human factors, or Ergonomics, is a science at the crossroads between psychology and engineering. Human factors use scientific methods to improve system performance and prevent unintended harm (Carayon and Wood, 2010, Wolf et al., 2021, The Chartered Institute of Ergonomics & Human Factors, 2019). In this context, the system means the organisational system. Human factors aim to design all aspects of a working system to support human performance and safety, for instance, communication between teams, designing protective equipment, and methods to improve

organisations and their culture, among others, as illustrated in the SHELL Model (Hawkins, 2017), see Figure 4. In healthcare, human factors often strive towards supporting the cognitive and physical work of QHP and promoting high-quality and safe patient care (Rodríguez and Hignett, 2021, Russ et al., 2013). Human factors can thus be cognitive tools, IT systems, equipment, etc. Human factors are about systems and not individual skills. The term ***human factor skills*** *(HFS)* will be used in this thesis as the skills QHP should train to manage the environment. HFS skills include social, cognitive, and decision-making skills and emphasise how the environment, the organisation and human psychology interact (Russ et al., 2013). This impacts the perspectives of the observations and the learning objectives in SBT. This thesis does not use the term Non-Technical Skills because it is an inaccurate and unhelpful descriptor, as Nestel et al. (2011) conclude. HFS are preferable to define the cognitive and social "skills" or "behaviours" in a positive sense (Nestel et al., 2011).

Figure 4: The SHELL Model (Hawkins, 2017).

This illustration is freely adapted from Hawkins. The SHELL model is a conceptual model of human factors that clarifies the relationship between humans, technology and the environment. The edges of the blocks are varied, illustrating each element's constant change. ***Software:*** *procedures, policies, rules.* ***Hardware:*** *tool, building, equipment, facilities.* ***Liveware*** *(individual/teams): communication, leadership, culture, norms, knowledge, attitudes, stress.* ***Environment:*** *physical, organisational, political, economic.*



Promoting safety covers minimising risks and harm to patients and QHP. Safety is one of the cornerstones in today's healthcare work (Oldland et al., 2019), encompassing an evolved multifaceted approach. The concept of safety can be divided into three distinct paradigms: Safety-I, Safety-II, and Safety-III, as proposed by Hollnagel and colleagues (Hollnagel et al., 2015, Wears et al., 2015, Leveson, 2020). Safety-I, the traditional model, focuses on preventing adverse events and errors through stringent guidelines and protocols. It emphasises a "no harm" approach and strives to identify and rectify weaknesses in the system. While Safety-I has significantly improved

patient safety, it has limitations in addressing complex and adaptive systems. Safety-II, on the other hand, acknowledges that healthcare systems are inherently complex and that humans often adapt to varying situations (Hollnagel, 2015). The safety-II paradigm focuses on understanding how things go right and encourages the study of successful performance, resilience, and system adaptability. It promotes a proactive approach to safety, allowing healthcare organisations to learn from everyday practices (Hollnagel, 2015). Safety-III extends the framework further, suggesting that healthcare systems should embrace complexity and actively seek opportunities to innovate and improve (Leveson, 2020). It advocates for organisations to create conditions that enable healthcare personnel to explore novel solutions to emerging challenges while maintaining a focus on safety. The evolution from Safety-I to Safety-II and Safety-III signifies a shift towards a more comprehensive and adaptable approach to patient safety. By incorporating these paradigms, healthcare institutions can better understand and address the complex nature of safety in healthcare, ultimately improving patient outcomes. In this thesis, the term ***patient safety*** will describe the theory and tasks around promoting safety in healthcare and the understanding underlying the SBT course and the fieldwork. Patient safety comprises understanding an adverse event as an unintended error in direct or indirect patient care.

Positive Interpersonal Behaviour covers professionalism, ethics, empathy, reflective practice, HFS, etc. *Medical and Technical competence* covers, e.g. medical knowledge, psychomotor skills, technical skills, critical thinking and problem-solving (Oldland et al., 2019). These skills are other cornerstones in today's healthcare work. CPD is, as mentioned, a key factor in Danish work life and, consequently, clinical healthcare (Kompetence Sekretariatet, 2013). In healthcare, CPD focuses mainly on gaining skills around handling acute situations, new equipment, new treatments and care approaches, and the skills are primarily bound to practical techniques, medical or technical knowledge or professionalism and skills necessary in acute critical situations (Abildgren et al., 2022). The concepts of positive interpersonal behaviour and medical and technical competence are joined in this thesis because competence is not only bound to the QHP's medical knowledge or technical competencies but also implicates the QHP's interpersonal, social and cognitive competencies. The QHP cannot separate these two types of competencies in their everyday work (Dyche, 2007). This thesis uses the term **competency** as the concept of gaining knowledge and skills. Competency is used for skills developed based on knowledge, experiences and behaviour towards qualified activities that can be internalised in everyday practice. Competency claims intentional, directed individual actions. This definition is inspired by the Danish pedagogic term action competencies (Jensen and Schnack, 1997).

Dreyfus and Dreyfus' (Dreyfus and Dreyfus, 1980) five levels of competency, going from novice to expert, are used in the observations and analysis to understand and interpret the level of competency the QHP have and works towards.

Didactics

When the QHP's HFS learning and training needs are identified, the didactics theory plans the intervention courses. As a theory of practical application of teaching and learning, didactics consist of a scientific approach or educational style to teach learners new knowledge and competencies (Ligozat and Almqvist, 2018). In that way, didactics are the foundation of the SimLEARN project's SBT intervention and cover adult learning theory, transformative learning theory, IPE theory, and SBT theory.

Adult learning differs from children's by seeking to make adults aware of and overcome previous inhibitions and gain new knowledge and competencies. To reach this, the adult learner ought to change childhood primary socialisation, which demands in-depth learning processes different from standard ways of learning new knowledge and skills. Adults are different learners than children because adults predominantly learn if the learning has clear goals, is meaningful and relevant, involves their experiences, and has a sense of ownership towards the learning goals (Clapper, 2010, Knowles, 1978, Merriam, 2017). Additionally, the adult learner is often independent and self-directed. The relationship between teacher and learner ought to be informal and characterised by collaboration, mutual respect and equality. Teachers with adult students should use a learner-centred approach to facilitate rather than direct learning (Herod, 2012). The core elements in the theory of **adult learning** are part of the didactic considerations made when planning the intervention of SimLEARN because the participants are qualified adults and, therefore, have their qualifications when participating in the SBT course. This theoretical approach is integrated into the planning and performance of the intervention and when analysing the transfer phase data.

Transformative learning is a well-established theory about transforming knowledge to competency through changes. **Transformative learning** is performed differently, depending on the context. It should be used individually and organisationally, as well as the learner's situation and readiness to learn. Transformative learning happens based on individual experiences and competencies, critical reflection, dialogue, holistic, context and trust. Moreover, transformative learning includes six principles: meaningfulness and exploration, psychological safety and openness to diversity, skills of fantasy and imagination, innovation and pushing of boundaries, analysis and understanding, and role models and inspiration. The overall purpose of transformative learning is for the individual to gain knowledge and competency and for the organisation to change toward a better and safer working environment (Illeris, 2014, Illeris and Ryan, 2020, Merriam, 2017). The core elements of transformative learning theory are used in this PhD study as didactic considerations, together with adult learning, as the aim is to develop QHP's HFS and investigate how they transform these HFS into competency in their clinical practice. This approach is used in the planning and performance of the intervention.

Interprofessional Education has evolved in recent decades, inspired by interprofessional collaboration. **Interprofessional Education** (IPE) refers to learning situations where learners from two or more health and social care professions are taught and trained to cultivate collaborative healthcare practice. IPE aims to practice safe, high-quality, accessible, patient-centred care within core competency domains: patient-centred care, interprofessional communication and teamwork, participatory leadership, values and ethics, roles and responsibilities for collaborative practice. The core domains vary worldwide but agree on those mentioned above. IPE was developed for undergraduate students. However, it is still used on a larger scale in team-based healthcare education courses (Rutherford-Hemming and Linder, 2023, Abildgren et al., 2022, World Health Organization, 2023a). As the clinical practice and the SBT intervention can include all kinds of QHP from the participating departments, IPE theory serves as the frame of the SBT courses. The approach is integrated in the planning and performance of the intervention and in analysing the data.

Simulation-based training has emerged as an essential pedagogical approach across diverse fields, encompassing aviation, healthcare, military, engineering, and beyond, where experiential learning is paramount (Eppich et al., 2011). **Simulation-based training** capitalises on simulated or replicated real-world environments, meticulously designed to offer hands-on experiences and foster practical skills development in a secure and controlled environment. It may occur within a designated simulation centre or the actual clinical practice setting, referred to as in situ training.

A defining hallmark of SBT is its ability to faithfully mimic real-world scenarios, replicating physical environments, equipment, tools, and processes relevant to the training objectives. Crucially, SBT allows learners to make mistakes without facing real-world repercussions. It is a dynamic platform for learners to cultivate specific skills or competencies, such as High Fidelity Simulation, permitting repeated iterations to improve skills and self-confidence. Performance feedback serves as a guiding example for learners to pinpoint strengths and areas of improvement. SBT scenarios can be finely tailored to meet precise learning objectives and adapt to participants' varying skill levels. Moreover, the remote accessibility of SBT facilitates training and practice from geographically dispersed locations, which is particularly beneficial for distributed teams. In the healthcare domain, various SBT modalities are deployed, ranging from virtual and augmented reality to computer-based and mannequin-based simulations, each offering unique advantages. While the initial setup costs for simulation systems can be substantial, the long-term cost-effectiveness of SBT surpasses traditional training methods (Hippe et al., 2020).

Simulation-based training bridges theoretical knowledge and practical application, granting learners invaluable hands-on experience within a controlled and secure milieu (AbdelFattah et al., 2018). The dichotomy of high-fidelity and low-fidelity simulations underscores SBT's adaptability. High-fidelity simulations employ cutting-edge technology to replicate real-world conditions precisely, rendering them ideal for training in complex medical scenarios. These simulations immerse learners in lifelike environments, fostering critical skill development and decision-making

under real-world pressures. Conversely, low-fidelity simulations employ basic equipment or models, offering cost-effective yet effective training options. While they may lack the realism and complexity of high-fidelity counterparts, low-fidelity simulations find utility in educational and emergency preparedness training contexts (Dieckmann et al., 2007, Issenberg et al., 2005, Okuda et al., 2009).

Debriefing constitutes an integral facet of high-fidelity SBT, using various forms as a structured post-training feedback mechanism. During debriefing sessions, learners and instructors engage in in-depth discussions, appraise performance, identify improvement areas, and extract valuable lessons from the simulated experience. This reflective process aids learners in connecting theoretical concepts with practical applications and offers insights into their decision-making processes. Effective debriefing enhances the educational value of SBT by fostering self-awareness and expediting skill development (Cheng et al., 2017a, Dieckmann et al., 2020, Rudolph et al., 2006, Steinwachs, 1992). This theoretical approach is integrated into the development and execution of the intervention and when analysing data.

The present project employs high-fidelity mannequin-based simulations in situ to simulate patient care scenarios. The debriefing model draws inspiration from approaches Dieckmann, Rudolph, and Steinwachs pioneered. Each debriefing session culminates in a roundtable discussion where participants encapsulate their most vital takeaways and articulate strategies for translating newfound knowledge into everyday clinical practice.

Transfer

Transfer is the key concept in the project and covers transforming and implementing newly learned knowledge and skills into competency and culture change. To explore if and how transfer happens and becomes competency among QHP, the following understanding of the transfer theory is the foundation of how transfer is interpreted in this PhD project. Transfer is a social process and involves more than cognitive processes. Training is only helpful if translated into competency (Yamnill and McLean, 2001). Transfer is the process of applying newly learned into competency in the everyday; in other words, moving knowledge from one context to another to change old knowledge to new and improved knowledge. Individual competency develops through transfer, resituation and transformation. The participant moves (transfers) learning from one context to another, adapting (resituation) what is learned into a new context and implementing (transforming) this to competency (Dohn and Hachmann, 2020). Organisational competency also develops through transfer, resituation and transformation. However, this process claims organisational equity and cultural changes. Billing emphasises that automatic transfer should not be assumed and that there are differences between novices' and experts' transfer processes. Furthermore, transfer improves if the learning-transfer process contains cooperative methods, training, reflection, and feedback on performance and if the transfer process is supported by re-training, re-learning, and socio-cultural factors (Billing, 2007). In this thesis, **transfer** is used as the process of transfer learning from SBT to clinical practice, adapting the learning into the QHP's

patterns of action in the everyday and implementing the learned into competency. The theoretical foundation is used as a benchmark in assessing if transfer has occurred.

Retention of skills covers the progression of retaining learned skills, meaning that the QHP can retrieve the skills in future situations comparable with the situation in which the skills are learned. Successfully retained skills boost individuals' confidence and motivation to engage in supplementary learning, fostering a positive cycle of skill development (Bandura, 1991). Retention aligns with the principles of CPD, enabling QHP to continually build upon their existing skill base as they encounter new challenges (Merriam and Baumgartner, 2020). Retention has a crucial role in ensuring transfer of new learning's long-term applicability and utility, offers numerous benefits, including sustainability, transferability, and problem-solving abilities and reduces the cognitive load during task execution, enabling individuals to allocate mental resources more effectively. **Retention of skills** leads to increased patient safety and patient satisfaction, an improved working environment for QHP, and cost-effectiveness in the healthcare system. Further, high retention rates are associated with sustained proficiency levels, ensuring that individuals maintain a competitive edge in their fields (Ericsson et al., 1993, Sweller, 1994).

To sum up, the model of the theoretical framework (Figure 3, p. 18) visualizes an ongoing circular process from evaluating the current quality of care and extracting learning objectives, planning and carrying out theoretical and practical HFS training, transferring these to competency in clinical practice to a process of sustaining the new competencies and re-evaluate the clinical practice. Each element builds upon the prior element. This process complements the known iterative Plan-Do-Study-Act cycle of improving quality in healthcare (Taylor et al., 2014). Further, this theoretical framework explains my theoretical standpoint, and it matches the helix process of phenomenological-hermeneutics and thus facilitates the research of transfer.

5. Methods and Study Design

This chapter describes the methods and study designs of the incorporated substudies in this thesis.

Methodology and Methods

This PhD study comprises two methods:

- Systematic review to gain knowledge of the effectiveness of SBT
- Ethnography to gain knowledge of the transfer of HFS skills to competency after SBT

Systematic Review

The background showed evidence that the effect of SBT was mainly on undergraduate HFS and technical skills. The purpose, thus, was to gain an explicit and coherent preunderstanding of the existing literature about the effectiveness of SBT with QHP focusing on HFS; the starting point of this PhD study was a systematic review to investigate the effectiveness of using SBT to train QHP in HFS (Abildgren et al., 2022).

Method

The preparation and performance of the systematic review were inspired by AMSTAR 2-criteria (A MeaSurement Tool to Assess systematic Reviews), which was used to prepare the review (Shea et al., 2017). The protocol was registered and published in the International Prospective Register of Systematic Reviews (PROSPERO) v. 2019 (Page et al., 2018) – ID: CRD42021118670. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement v. 2020 (Page et al., 2021) was used to report the systematic review (Abildgren et al., 2022).

Search strategy

The conceptualising model SPICE (Setting, Perspective/Population, Intervention, Comparison and Evaluation) were used to formulate questions, keywords and the search process (Cooke et al., 2012, Booth, 2006). The elements were outlined as ***Setting*** = All in-hospital healthcare specialisms and units; ***Population*** = QHP; ***Intervention*** = SBT to teach HFS; ***Comparison*** = SBT versus no training or lectures in a classroom; and ***Evaluation*** = improvements in QHPs HFS (Abildgren et al., 2022). The focus was on in-hospital QHP with direct patient contact; therefore, dentists and pharmacologists were excluded. The search strategy was developed in cooperation with a research information specialist. The search string used Boolean operators to combine keywords and blocks. Near operators define a connection between two or more words, for instance, *simulation* AND *education, course, training*, etc. Moreover, truncation, phrase search, proximity search and citation search were employed.

The search strategy, as shown in Table 2, is developed to locate studies about the effectiveness.

Table 2: Search strategy (the effectiveness of training human factor skills through simulation-based training.
The example presents the search in the Medline Database. The subject headings (EXP) and free-text keywords (MP) combined with Boolean operators OR/AND and the use of near operators (ADJx). X marks the number of words away from the keyword.

Block	Search – Medline example
Simulation-based training	exp simulation training/ OR (simulat* adj5 (educat* or cours* or workshop* or boot-camp* or bootcamp* or learn* or experienc* or curricul* or framework* or teach* or guid* or coach* or supervis* or seminar* or lectur* or round* or tutor* or mentor* or program* or training* or event*)).mp. OR (high adj3 fidelity adj5 (educat* or cours* or workshop* or boot-camp* or bootcamp* or learn* or experienc* or curricul* or framework* or teach* or guid* or coach* or supervis* or seminar* or lectur* or round* or tutor* or mentor* or program* or training* or event*)).mp. OR (hi-fi* adj5 (educat* or cours* or workshop* or boot-camp* or bootcamp* or learn* or experienc* or curricul* or framework* or teach* or guid* or coach* or supervis* or seminar* or lectur* or round* or tutor* or mentor* or program* or training* or event*)).mp. OR (in adj3 situ adj5 (educat* or cours* or workshop* or boot-camp* or bootcamp* or learn* or experienc* or curricul* or framework* or teach* or guid* or coach* or supervis* or seminar* or lectur* or round* or tutor* or mentor* or program* or training* or event*)).mp. OR (insitu adj5 (educat* or cours* or workshop* or boot-camp* or bootcamp* or learn* or experienc* or curricul* or framework* or teach* or guid* or coach* or supervis* or seminar* or lectur* or round* or tutor* or mentor* or program* or training* or event*)).mp. OR (full adj3 scale* adj5 (educat* or cours* or workshop* or boot-camp* or bootcamp* or learn* or experienc* or curricul* or framework* or teach* or guid* or coach* or supervis* or seminar* or lectur* or round* or tutor* or mentor* or program* or training* or event*)).mp.
Human factor skills	NTS.mp. OR (non adj5 technical adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (non-technical adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (nontechnical adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (soft adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR exp leadership/ OR (leadership* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR exp fatigue/ OR (fatigue* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR exp cooperative behavior/ OR (cooperat* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR exp intersectoral collaboration/ OR (collabor* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR exp decision making/ OR (decision adj3 making* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR exp patient care team/ OR (teamwork* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (safe* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (error* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR exp cultural competency/ OR (cultural adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR exp social skills/ OR (social adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (followership* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (CRM* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (crisis adj3 resource adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR exp interprofessional relations/ OR (interprof* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (inter-prof* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (interhuman adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (inter-human* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (interact* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (inter-act* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR exp interdisciplinary communication/ OR (interperson* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (inter-person* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (interdiscipli* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (inter-disciplinary* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (multidiscipli* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR (multi-discipli** adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR exp attitude of health personnel/ OR (doctor adj3 nurse adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp. OR exp physician-nurse relation/ OR (physician adj3 nurse adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.

Analysis process

A content analysis (Stemler, 2000, Krippendorff, 2018) was used as a research tool to assess SBT's effectiveness. Content analyses are systematic and objective research methods. Content analyses enable qualitative and quantitative analysis by revealing patterns, themes, or concepts within a data set. Stemler's inductive technique, from open coding to creating themes and abstractions, was used to analyse the content (Stemler, 2000).

Literatur search

The choice of the eight databases was based on recommendations within the literature (Cooper et al., 2018, Frandsen et al., 2019) and aimed to gain an exhaustive result from the existing literature. A detailed example of the block search is provided in Appendix 2.

Selection and critical appraisal

In the study selection process, Covidence version 2019 (108) was used as a screening and data extraction tool based on a pre-piloted guide of inclusion and exclusion criteria by three authors of Paper I. The selection process was documented in a PRISMA chart in Paper I, Figure 1, p4 (Abildgren et al., 2022). All study designs and publication types were included apart from reviews, protocols and conference abstracts. Conflicts were resolved through dialogue.

The included studies were critically appraised and labelled with a high, medium or low-reliability rating for effectiveness analysis. The critical appraisal included all studies, although the studies were of varying quality, e.g., unsuitable assessment methods, favouring technical skills in assessing

effectiveness. The critical appraisal was used to indicate the study's validity and reliability. Inspired by “the Matrix Method” (Gerrard, 2011), a matrix of the included studies containing relevant information about each study was developed. A focused matrix was published in Paper I, Table 3, pp. 6-10 (Abildgren et al., 2022).

Ethnography

Ethnographic fieldwork was applied as a complementary approach to investigate the transfer of HFS, as this method allowed one to observe what happens during and after an SBT course, follow what was said and talked about, and compare this to what actually happened. To investigate how transfer emerges. Data was gathered through ethnography to acquire in-depth knowledge of how QHP transfers HFS from SBT to competency in clinical practice.

Method

Ethnography is to understand and describe a native’s point of view; the culture of a system is embedded in the natives' explicit and tacit knowledge, and it is used to describe human behaviour in terms of meaning. Moreover, ethnography can yield empirical data about people's lives and actions in specific situations. According to James P. Spradley, ethnography aims to understand lived life from another point of view by learning from people's way of living (Spradley, 1980). The ethnographic method used in this study was inspired by Spradley's (1980) and Pedersen and Humle’s (2016) approaches to ethnographic fieldwork (Spradley, 1980, Pedersen and Humle, 2016). Those two approaches were chosen firstly because Spradley's approach provided an opportunity to investigate and participate in different settings of clinical practice and the everyday QHP. Further, Spradley has five types of involvement in the system being studied: from non-participation to complete participation, i.e. from passive participation as ‘a fly on the wall’ to active participation as helping with practical chores or informal conversations with the participants. Secondly, Pedersen and Humle's approach provides an organisational approach to ethnography and combines ethnographical methods with organisational phenomena, e.g. strategy and policy making, and analytical perspectives, e.g. sensemaking and narratives (Pedersen and Humle, 2016). Both the native perspective and the organisational perspective are essential when understanding how HFS becomes competency.

The ethnography fieldwork makes it possible to operationalise the phenomenological-hermeneutic to study the lived lives of individuals and within systems and how individuals think, act, see, hear and speak. The researcher does not study the participants but seeks to learn, observe and discover how transfer happens. According to Spradley, the ethnographic process moves from broad descriptive observations through focus observation to selective observations of the natives (Spradley, 1980). According to Pedersen and Humle, the organisational ethnographic process focuses on the frames, practices, interactions and discourses natives are part of. The organisation is dynamic and has a fragmented network of social interactions (Pedersen and Humle, 2016). The incipient analysis narrows the observations in the focused and selective states. In the present study, the objective of the ethnography was to understand, describe and explain how QHP

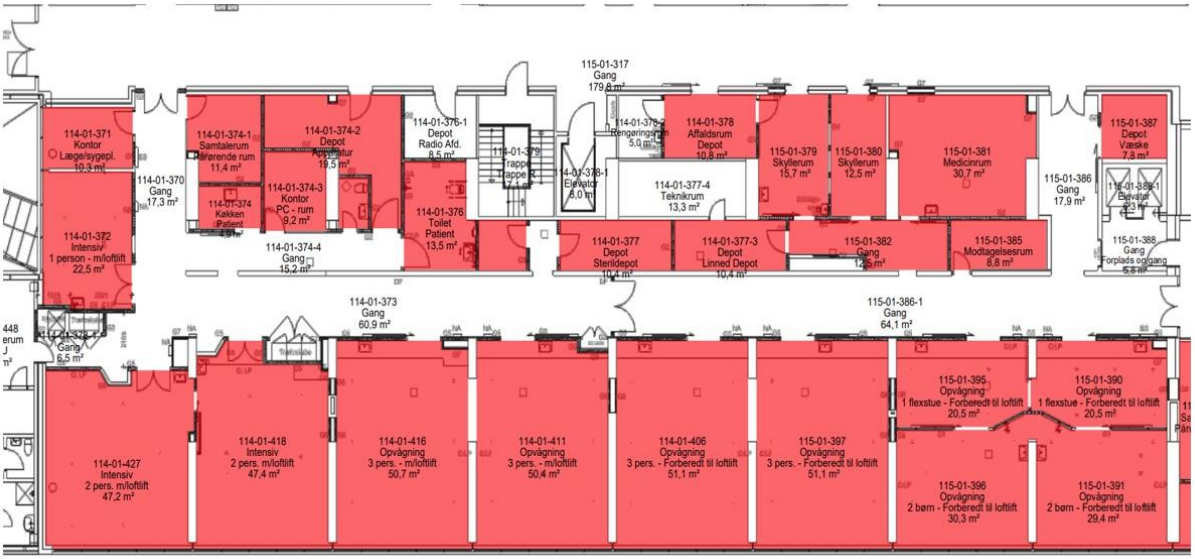
transfers learning from SBT to competency in clinical practice, looking at both QHP and the surrounding organisation.

This study used GoPro Hero 5 cameras and field notes to document the observations and discussions of the two researchers' perspectives. Spradley describes a matrix of nine items to structure the field notes: place(s), object(s), who is involved, related action(s), activities, the goal of action(s), time, felt or expressed emotions (Spradley, 1980) and practices, interactions, discourses, frames, tensions and narratives of the organisation (Pedersen and Humle, 2016).

Settings

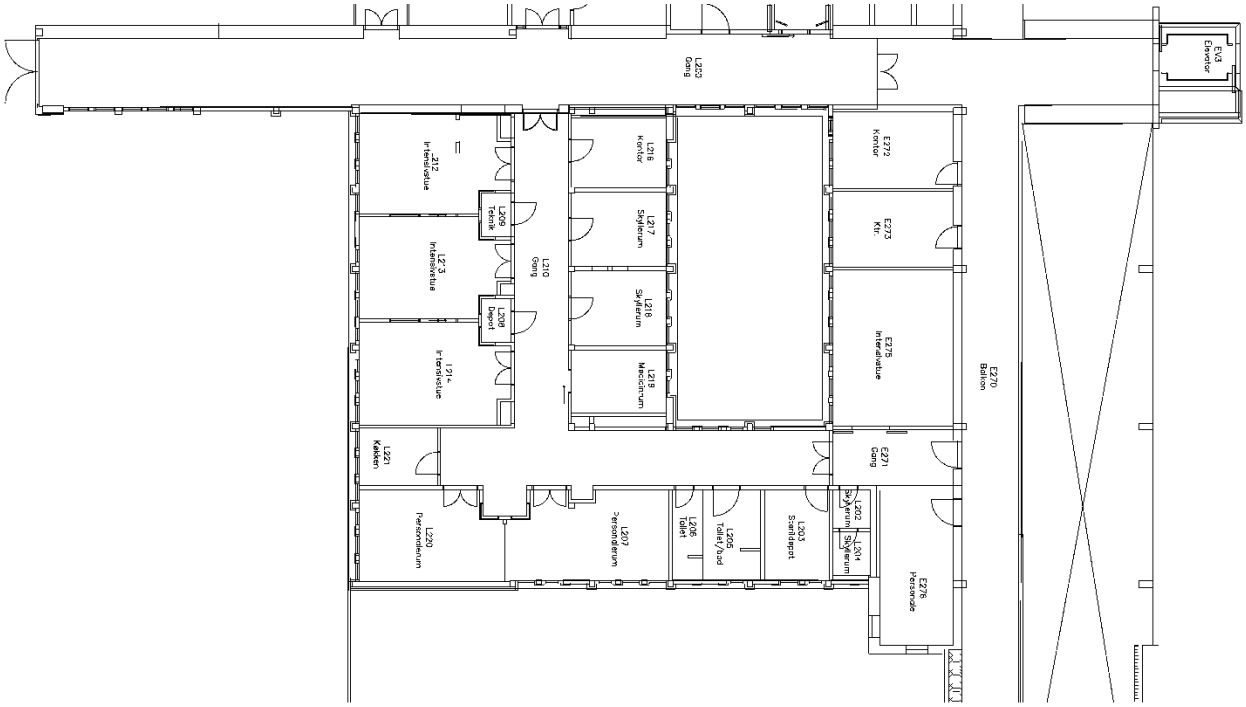
The study setting was two Danish hospitals in the Region of Southern Denmark, a university hospital (965 beds, ~11,000 personnel) and a local hospital (302 beds, ~2,600 personnel). Four different departments were included in the study: two critical care wards (one at the university hospital and one in the local hospital), one emergency ward, and an infectious disease ward. The departments consisted of 54 beds and 8 beds, respectively, in the ICUs, 42 beds in the emergency department and 15 beds in the infectious disease department. Only one ward in the university hospital ICU participated. The four settings can be seen in Figure 5, illustrated by each ward's floor plan.

Figure 5: Settings.
5a: Critical Care ward, university hospital.

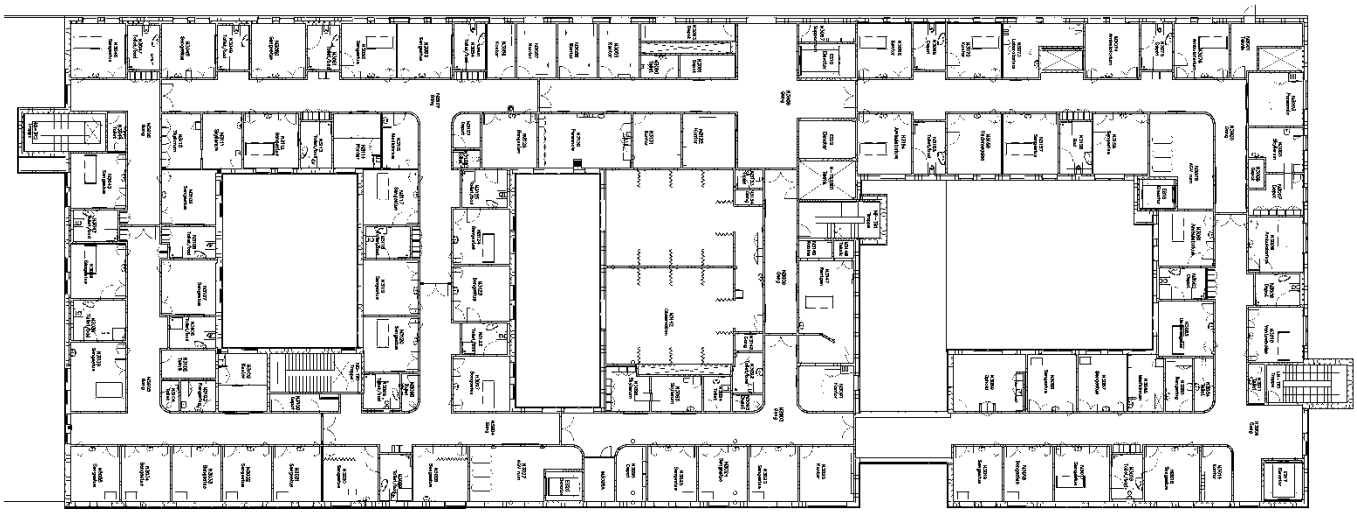


5b: Infectious Disease ward, university hospital.

5c: Critical Care ward, local hospital.



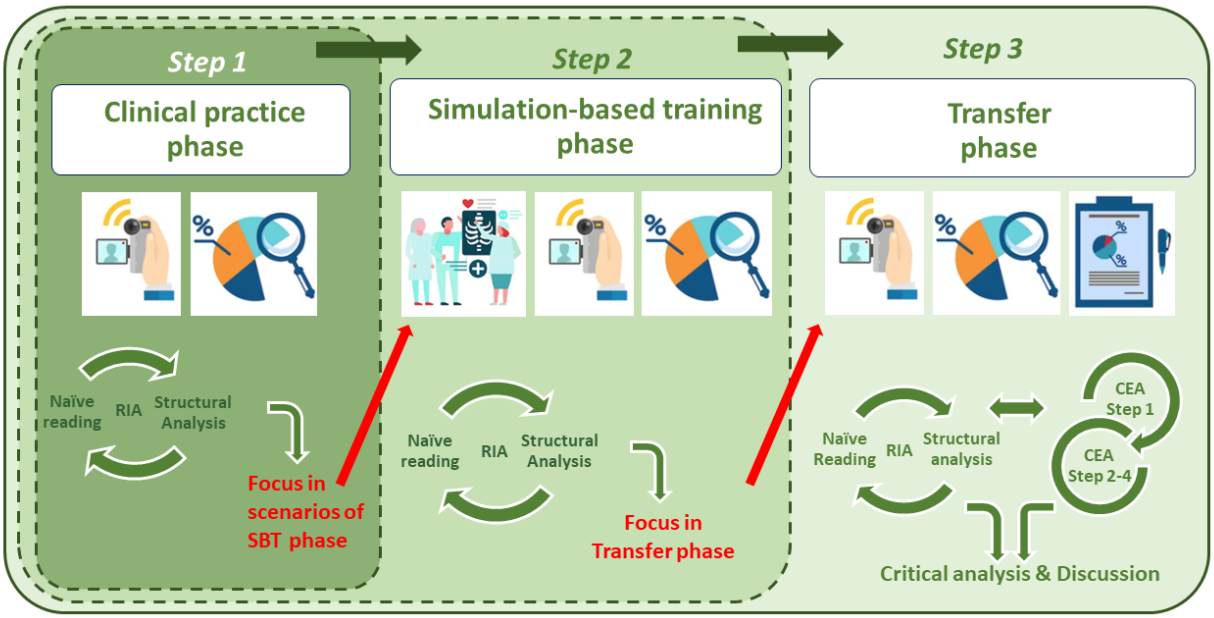
5d: Emergency ward, local hospital.



Data collection

The ethnographic data was collected in three phases by following QHP. Figure 6 shows the three phases of data collection. The steps consist of 1) Clinical practice phase, which is descriptive observations of QHPs' use of HFS in clinical practice. 2) In the SBT phase, the focus was on observation of how QHP talked about, acted, expressed, and felt emotions around HFS during the SBT course. After steps 1 and 2, the initial analysis led to the focus in the following ethnographic step. 3) Transfer phase, specific observations on changes in QHP's use of HFS in everyday clinical practice after participating in SBT.

Figure 6: The three-phased data collection.



Recruitment and Sample

Through a discussion in the research group, preferred departments are selected from the following inclusion criteria: Experiences with simulation and a high number of adverse events around HFS. The departments are preferably compatible, and the department wants to prioritise time working with HFS. Four departments are contacted first face-to-face and then by mail with details of a collaboration contract (see mail in Appendix 3 [Danish]) and participation commitment (see Appendix 4 [Danish]).

All four wards agreed to participate, and contracts and appointments were made with the heads of the QHP. An introduction meeting was held face-to-face with the ward's QHP. At this meeting, the project's background, aim and methods were presented, they were introduced to the HFS concept, and information material was handed out (see Appendix 5, PowerPoint, Poster, preparation info [Danish]). One to two weeks before the SBT intervention, an e-mail was sent to the heads who distributed it to the QHP. The mail contained short information about the project, the dates of data collection and a link to a 7-minute screencast with an introduction to HFS

developed for the study as preparation for the SBT (see screencast https://youtu.be/NFlCahZw8x8 [Danish]).

The participants were at-work QHP (doctors, nurses, physiotherapists, radiologists, nurse assistants, technicians and secretaries), medical students, and nursing students in the ward. In cooperation with the heads of the wards, the participants were selected from the duty schedules. Thus, the competency on the day was presumed to cover novice to expert. However, all personnel could decline participation just before the SBT participants gave informed consent (see Appendix 6 [Danish]).

Intervention

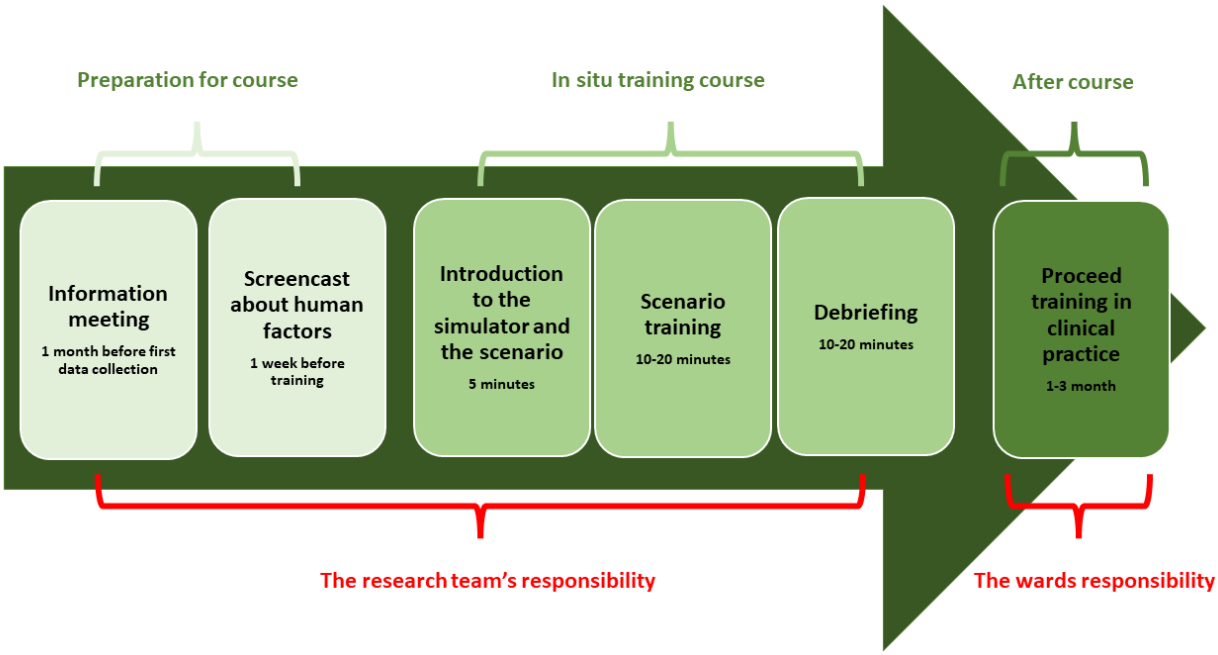
The intervention comprises preparatory information meetings in each ward with leaders and possible participating QHP (~1 month before data collection begins), a screencast about HFS mailed to all the ward personnel (~1 week before SBT) and two identical days of SBT in each participating ward. The information meetings include a presentation of the two researchers who gathered data, the SimLEARN project, and the aims, methods, and plan for the data collection. Leaders and QHP can also ask clarifying questions and express thoughts and concerns.

Due to Abildgren's expertise in SBT, she forms the HFS objectives and develops the training scenarios based on the themes that emerge from the initial analysis of the clinical phase. The study objectives and methods are presented in a pre-training workshop with external expert facilitators who will facilitate the SBT. Further, the expert facilitators are aligned with the debriefing process and debriefing model. The primary focus on HFS, reflecting on the trained cases and making analogies to similar situations in the clinical practice, are emphasised for the facilitators. A pocket-size chart with HFS and examples of behaviour was developed and handed to the facilitators (see Appendix 7) [Danish]. The two primary researchers, two operators, and four expert facilitators in the local simulation centre tested and validated the scenarios. A Danish example of a scenario can be seen in Appendix 8 [Danish].

Each SBT day consists of three high-fidelity training sessions. Before each scenario, the participants are introduced to the simulator and the situation of the scenario (5 minutes), 10-20 minutes SBT, and a 25-30-minute debriefing led by the external expert facilitators (1 doctor, 1 nurse). Four to six personnel participate in each scenario. The clinicians can participate in one to three of the scenarios. The two leading researchers observe the sessions, and GoPro cameras record the sessions from three different positions. Figure 7 illustrates the total intervention.

After the two days of SBT, the wards' participants and heads are responsible for continued training and internalising the newly trained HFS. The heads are provided with a comprehensive list of the recently gained skills, attention points, and suggestions for supplementary training after the SBT course. See an example of the list of acquired skills, attention points and recommendations in Appendix 9 [Danish].

Figure 7: The in situ training intervention.



Data Analysis and Interpretation

This section first presents the study's analysis and interpretation methods, then the hybrid method and how the hybrid method has to be understood.

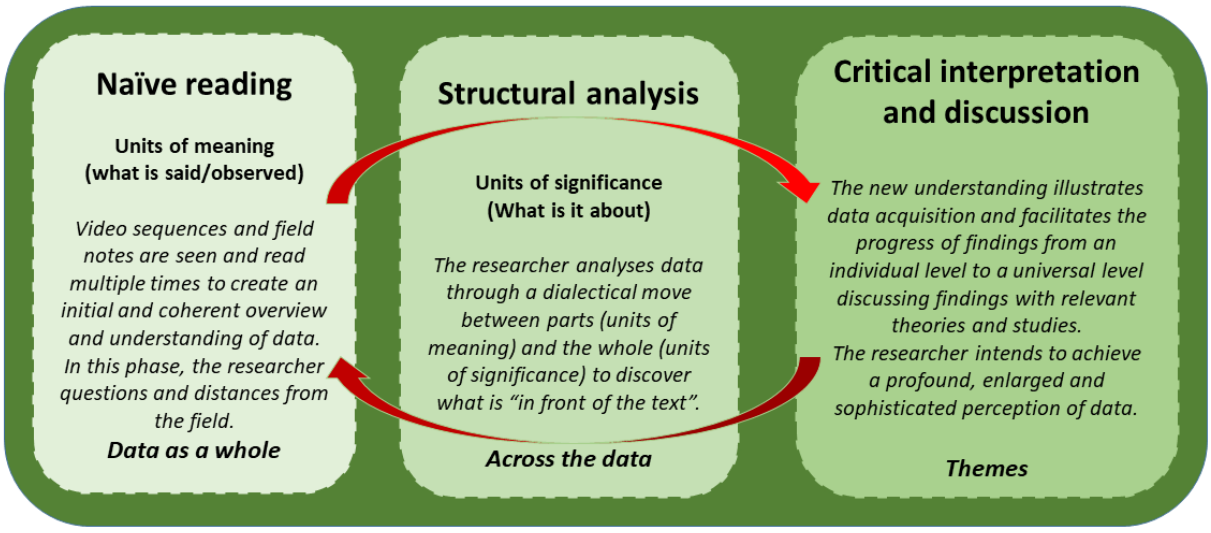
The complexity of the research question of tracking changes in human behaviour needed an analysis and interpretation approach that comprised at least a theoretical frame that integrated social, psychological and cognitive aspects of behaviour, an approach to describe, understand and explain how HFS becomes a clinical competency and investigate how HFS is taught, transferred and transformed to competency in the complex clinical everyday. No existing method found could comprise these requirements, which the systematic review results (Paper I) backed (Abildgren et al., 2022). Consequently, developing a method that could explore transfer of knowledge from a simulation-based course to competency in clinical practice was necessary. The starting point was two known analytical approaches, each meeting parts of the needs, and a hybrid method called RI-CEA was the answer. The hybrid method consists of a phenomenological-hermeneutic Ricœur-inspired analytical approach (RIA) and a Cognitive Event Analysis (CEA) of ethnographic data from a healthcare setting. Each analytical approach will be elaborated on, first as the original analytical approaches, then how the hybrid method is used in this study's analysis and interpretation of data. The hybrid method is published as the methodological paper: Transfer human factor skills from simulation-based training to competency in clinical practice – a demonstration of a hybrid method for assessing transfer of learning (Paper II) (Abildgren et al., 2023).

Ricœur-Inspired Analytical Approach

The phenomenological-hermeneutic Ricœur-inspired analytical approach (RIA) is inspired by Ricœur's thinking about ways of *"being in the world"* (Pedersen, 1999, Agerskov et al., 2015, Larsen et al., 2023, Hounsgaard, 2004, Simonÿ et al., 2018, Svenningsen et al., 2016), meaning the subjective experience of individuals and their comprehension of the lived life. Healthcare researchers have, with reference to Ricœur's writings on language, reflection and text comprehension, extended Ricœur's philosophy for analysing narratives, language, experiences, interviews, and ethnographic data (Pedersen, 1999, Nygren and Blom, 2001, Geanellos, 2000, Simonÿ et al., 2018, Agerskov et al., 2015). According to Ricœur, humans are affected by all real-life situations and orient themselves as part of them. Instead of behaving rationally under universal rules, humans act based on their lived experience and existence in the world (Ricoeur, 1976).

The Ricœur inspired analytical process consists of three levels: 1) naïve reading, 2) structural analysis and 3) critical interpretation and discussion (Ricoeur, 1976, Lindseth and Norberg, 2004). In the naïve reading, the researcher notes ideas, thoughts and impressions. The researcher creates an overview and an interconnected understanding of data questions and distances oneself from the actual situation. The structural analysis is where patterns, subthemes and themes are found across the data. The critical interpretation and discussion are where subthemes and themes about other theories and research are described, explained and understood. At this level, the findings are moved from the individual to a universal level (Pedersen, 1999, Simonÿ et al., 2018). Figure 8 illustrates the analytical process as a dialectic process moving in a hermeneutical helix between naïve reading, structural analysis, and critical interpretation and discussion. This dialectic process provides an enlarged, profound and sophisticated understanding of the individual participants' transformation of HFS through a movement between parts and the whole.

Figure 8: Ricœur-inspired approach to data analyses (Abildgren et al., 2023).



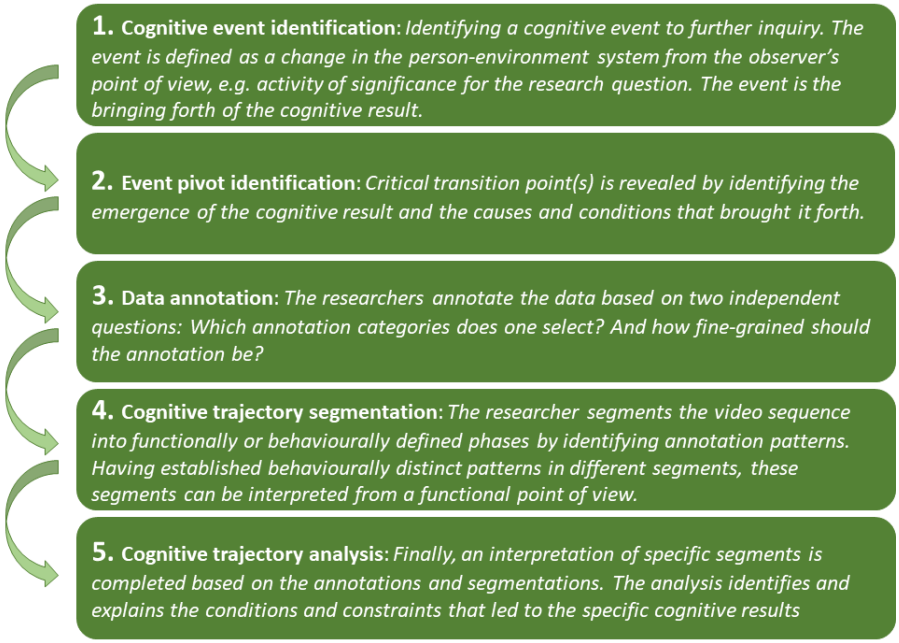
As mentioned above, this study's data are video recordings, field notes and reflections. This study understands the task of observing video sequences and reading field notes as similar to how Ricœur views texts or narratives in the sense that the video sequences have "*left*" the original field and the participants with meaning to interpret. This resembles Ricœurs' claim that a text "*leaves*" the author's intentions. The object, thus, becomes the shared meaning of the video or text rather than the original intentions of the author or participants in the recording. The researcher "*listens*" to the meaning of the video recordings or field notes and remains open to new details for understanding what emerges in "*front of the text*" (Ricoeur, 1993, Wood, 1991). Opening the recordings or field notes through intuitive listening adds a first-person researcher's perspective and grounds the researcher in the analysis process by reclaiming the field, feelings, senses, and thoughts that have escaped the researcher.

Cognitive Event Analysis

The Cognitive Event Analysis has scientific roots in cognitive science, specifically cognitive ethnography and distributed cognition (Hutchins, 1995). Cognitive science aims to understand people's thinking and behaviour by examining human tasks and exploring thinking processes (Ball and Ormerod, 2000, Bender et al., 2010). Distributed cognition has interdisciplinary roots, however, with a phenomenological understanding of the human as embedded in brain, body, environment and social interactions (Goodwin, 2000, Hutchins, 1995, Trasmundi, 2020) and that cognitive processes are distributed across brain, body, environment and over time (Hollan et al., 2000). Therefore, cognition is distributed in a network of relations and cannot be reduced to neural functions (Hutchins, 1995). CEA is built on the thinking of Hutchins, Järviletho, Steffensen and others (Hutchins, 1995, Steffensen et al., 2016, Steffensen, 2016, Järvilehto, 1998). In the paper *Integrating Cognitive Ethnography and Phenomenology: Rethinking the Study of Patient Safety in Healthcare Organisations* (Lebahn-Hadidi, 2021) (Paper A), an integration of cognitive and phenomenological research is proven possible and valuable for understanding complex situations in healthcare.

Cognitive Event Analysis uses ethnographic video data to study human cognition by focusing on bodily and inter-bodily dynamics (Trasmundi, 2020). Because of its interactivity-based method, CEA can explore cognitive processes and examine the bodily and inter-bodily dynamics of movements, gestures, symbols and activities. CEA makes it possible to explore the real-time dynamics of human behaviour by "*zooming*" in and out on the organisational domain and investigating the coordination between agent(s) and environment extended in time and space to reach sense-making. CEA's starting point is to identify the cognitive result. Consequently, the outcome of a given cognitive process works backwards from this result to gain awareness of what caused or conditioned this result and then understand the cognitive system and the cognitive trajectory (Steffensen et al., 2016). To do so, CEA follows five steps. The five steps are illustrated in Figure 9:

Figure 9: The five steps of Cognitive Event Analysis (Steffensen et al., 2016).



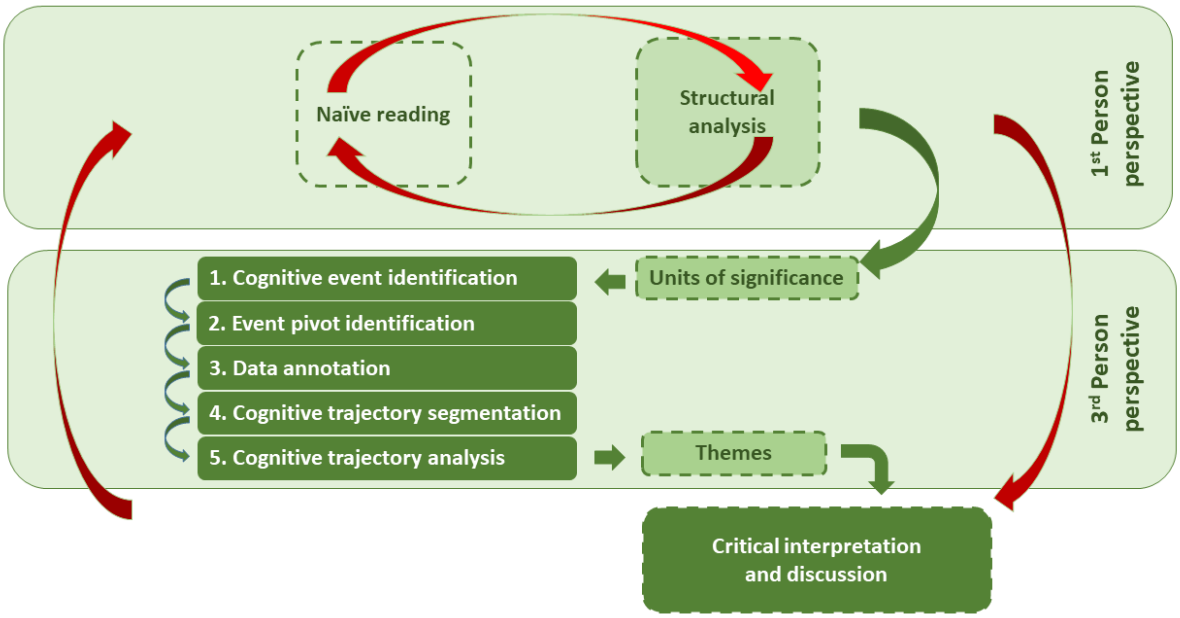
A Hybrid Method

Either RIA or CEA could answer the research question alone. It was necessary to evolve a method that offers descriptions and explanations of what, how and if the transfer happens and at which level, individual, intercollegiate and organisational. The results are the RI-CEA method used to analyse the whole data set.

During the data collecting phases, data from the clinical and SBT phases are analysed incipiently using RIA. The incipient analysis consists of naïve reading and structural analysis, as described in the RIA chapter, resulting in units of significance. The unit of significance shapes the observations in the following phase. All data are interpreted as a whole with RI-CEA after data collection in the transfer phase is conducted.

Figure 10 illustrates that the first analytic step is RIA, a naïve reading followed by a structural analysis; this step gains a first-person perspective of the participant's lived experiences. In the structural analysis, the dialectic movements between past and future, parts and whole, lead to units of significance. These significant units are CEA's starting point. CEA gain a third-person perspective on situations to capture transfer; in other words, are changes in the QHP's actions detectable between the clinical and the transfer phase, and do the SBT or transfer phase data describe, explain, offer help to understand actions or support interpretations? Finally, the emerging themes are critically analysed and discussed. The hybrid method is demonstrated in Paper II (Abildgren et al., 2023).

Figure 10: RI-CEA, the evolved hybrid method.



Ethical Considerations

The study follows the existing rules of ethical and responsible research conduct, including the Helsinki Declaration (131) and the Nuremberg Code (Government, 2005). The project is registered by the Ethical Board of the Region of Southern Denmark (ID 20182000-140) and approved by the Danish Data Protection Agency (ID 19/14608). It follows the requirements of The Danish Code of Conduct for Research Integrity (Ministry of Higher Education and Science, 2014). (See approvals in Appendix 10).

All QHP in participating wards were informed orally about the project, the data collection methods and data protection, and that participation was voluntary. Anonymity in the ethnography or SBT course about QHP's participation was impossible to assure. Participants (QHP and patients) and facilitators who participated in the video recordings, SBT, and formal and informal talks received oral and written information about the study before giving informed consent. Participants could opt to decline participation without consequences. As data was gathered using video cameras following QHP in their everyday, focusing on the QHP's HFS, it was impossible to avoid recording patients, relatives, and others visiting the wards in advance. Consequently, each time an 'outsider' entered the recording zone, the camera paused or faced the floor until the person(s) were informed and accepted participation. Further, ward posters informed QHP, patients, relatives and others about the project. Contact information on the posters made it possible to reach out.

Ethnography requires more than formal permissions, information, and content due to people's involvement and participation in social contexts. Ethnography is based on relational and sequential processes rather than a contractual agreement, and the trust between the participants and the researcher often develops to include access to additional personal and in-depth thoughts and

feelings than in other kinds of research. Social contexts and activities require a continuing ethical reflection, mutual respect and responsibility for the researcher (Murphy and Dingwall, 2007).

Field notes were anonymised, managed confidentially, and stored according to existing guidelines. Video files were stored and kept confidential using a secured online research platform provided by OPEN (OPEN), a supporting unit for health science research in the Region of Southern Denmark. All video file analyses were conducted within the secured online environment of OPEN. The anonymity of the participants in video recordings is more complex than in interviews or 'old-fashioned' ethnography with pen and paper. The camera tapes everything the 'eye sees'; thus, the researchers are responsible for protecting unintended participants, for instance, QHP, patients or relatives passing in the hallway or entering offices, etc. The researcher's most important obligation is not to expose participants or others who pass the field of interest. Published data material has been anonymised or concealed so that participants are unrecognisable.

My role as a researcher, nurse and teacher

As a researcher, expert nurse and teacher, I was aware of the intertwined role through ethnography and, consequently, my fundamental values and knowledge of patient care. In the field, I was open about my professional competencies as a researcher, critical care nurse, and SBT specialist. I used my professional qualification to vary my participation from fully observing to participating in caring for patients. It was important to me to establish, support and maintain a respectful and trustful relationship with the participants and the ward, to be open, curious and interested in describing and unfolding the participants' natural behaviour and everyday work routines. Although the openness around my competencies was mainly an advantage, it sometimes challenged me during some observations, where I felt the urge to interfere in the situation based on my professionalism. In these situations, I had to balance the role between the quality of care and objectivity as a researcher. Nevertheless, patient safety was always the overarching premise.

6. Findings

This chapter describes the main findings. First, an overview of the systematic review results is followed by a description of the ethnographic dataset. Next, the deductions of the incipient *naïve readings* and *structural analyses* in Step 1 and Step 2 (see Figure 8, p. 35 and figure 4 p.20) are presented, as these findings jointly led to the focus in the following step. Then, the findings from Step 3 (see Figure 10, p.38), the *naïve reading* of the entire data, will be presented, followed by the *structural analysis.* Next, findings from the *CEA* will be presented, leading to the emerging themes. Finally, the results are elaborated on and discussed in the discussion section to answer the thesis' overall research question, described on p. 15.

The findings from each substudy are described in an overview in Table 3; each provided understanding that led to the answer to the overall research question. Paper I (systematic review) reveals the findings of the effectiveness of training QHP's HFS through SBT. These findings are presented in the background of this thesis (Chapter 2). Paper II (method development) demonstrates the hybrid method RI-CEA. The development of RI-CEA was necessary to answer the research question of how transfer happens. These findings are presented in the method section of this thesis (Chapter 5). Paper A and Paper B, which I co-authored, showed two different perspectives on how QHP uses HFS in their effort to maintain a high quality of care and safety. Paper A (coping with adverse events) demonstrates the integration of phenomenology and CEA and analyses the complex clinical practice around administering medicine to a patient. Paper B (non-interruption zones) investigates QHP's use of HFS in the medicine room. The findings presented in Paper A and Paper B are integrated into my analyses to support the critical interpretation and discussion of the overall findings, and these findings will only be presented briefly. For further details, see Paper A and Paper B in Chapter 12. Paper III: Presents the complete findings of how QHP transfers HFS, trained in SBT, to competency in clinical practice (Papers I-III are attached in Chapter 12).

Table 3: Overview of the main findings.

Study/Paper	Main findings from the study
Study 1 - Paper I ***Systematic review***	SBT improves QHP's HFS and is trainable, similar to technical skills. Research on transfer of HFS to competency in clinical practice and retention of HFS in clinical practice is insufficient, though crucial for understanding its impact on patient safety.
Study 2 - Paper II ***Hybrid analytical method***	RI-CEA - The hybrid method offers a systematic and in-depth method for understanding the transfer of HFS from SBT to critical practice. This research represents the initial stage in creating a transfer tool.
Study A - Paper A ***Coping with adverse event threats***	Ethnography can accommodate cognitive and phenomenological research aims and supports the mission of understanding healthcare adverse event responses. Further, the research contributes to patient safety studies by highlighting conflicting safety logics within safe medicine administration.
Study B - Paper B ***Collaboration or non-interruptions in the medical room***	Nurses collaborate extensively in medicine rooms, although it is an individual task, for local safety, including mentoring less experienced colleagues. SBT raises awareness, supporting safe medicine administration.
Study 3 - Paper III ***Findings from the ethnographic study***	Transfer of HFS from SBT to competency in clinical practice depends on individual, intercollegiate and organisational support in the everyday. Findings suggest that while individual and intercollegiate transfer occurs, the organisational support needs to be improved to stimulate the transfer, transformation and retention of HFS.

Systematic review

The systematic review (Paper I) shows that the transfer of HFS needs to be revised. Many assessment tools are developed to make HFS visible for changes and improvements during and immediately after the SBT of HFS. HFS is often adapted into technical skills (e.g. ABCDE, SBAR, behaviour markers (ask for timeout)) to make it visible. The systematic review in this thesis concludes that SBT is effective for training HFS among QHP. Still, the dispute of how to measure the development of HFS hinders comparing effectiveness. Further, it concludes that the culture of viewing HFS as innate and complicated to train is an ongoing problem and could be one of the obstacles in transferring the HFS from SBT to competency. Another finding shows that transfer to competency and retention of skills needs supplementary research (Abildgren et al., 2022). The conclusion served as both a pre-understanding of the field in focus and the take-off for the ethnographic study. My pre-understanding, as described in Chapter 1, was expanded with a profound theoretical background, which allowed me to open my world and put my prejudices into play, and the possibility of seeing the researched phenomenon from new perspectives.

Ethnographic dataset

The data collection was conducted between February 2019 and February 2020. The dataset comprises approximately 107 hours of ethnographic video recording, field notes and written reflections. The **Clinical phase** consists of 47 hours of video data, divided into eight days - two days of ethnographic fieldwork in each participating ward. 17 QHP participated as primary informants in the ethnography. The **SBT phase** consists of 52.5 hours of video data, divided into seven days of

SBT. 21 training sessions (1 session = 1 scenario and 1 debriefing) were conducted. The sessions were led by four expert facilitators (two doctors and two nurses), one doctor and one nurse in each session, and 45 QHP participated in the SBT course. In the infectious disease ward, only one training day was completed due to a lack of personnel and resources to participate. The **Transfer phase** consists of 7.5 hours of video data. Due to the COVID-19 pandemic restrictions, the Transfer phase was stopped after two days of data collection. Consequently, data from the Transfer phase are only from the local hospital.

Clinical phase – Incipient Analysis (RIA)

The naïve reading of data from the Clinical phase revealed areas of consideration and experiences of the clinical practice with a high-performance level and flow. The QHP's endless changing everyday where planned tasks are regularly interrupted due to new, urgent or critical tasks – receiving a new patient, taking a phone call, helping a colleague, assisting with a procedure or talking to a patient or relatives. Doctors' and nurses' stations, medicine rooms and hallways were busy as an anthill; everyone had their task, but often with an impact on their colleagues' tasks. Delivering messages, patients' vital parameters or asking for advice or help. The wards had different cultures around how to contact each other; nonetheless, QHP disturbed each other in tasks endlessly across all wards. Not to annoy but to complete an individual task. A heavy load of educational responsibilities on QHP, from competent to expert, was perceived.

The incipient structural analysis identified six themes: coordination, interruptions, educational responsibilities, teamwork, and situational awareness. These six themes were integrated as learning objectives in the SBT course. See the example of the clinical phase's structural analysis in Paper II, Figure 5_A, p 9.

Simulation-based training phase – Incipient Analysis (RIA)

The naïve reading of data from the SBT phase shed light on areas of consideration and experiences of a necessity for more HFS training. The QHP participated enthusiastically in training and expressed spontaneous relevance of the focus on HFS. A primary focus on training and learning technical skills was detected among the QHP, and following an absence of stress on, speaking of or practising HFS was noticed - Fulfilling the task was seemingly the goal. The training sessions opened a window for the QHP to look at their daily practices from a HFS point of view. This led to aha experiences among the participants during the debriefings and commitments to change and improve their HFS.

The incipient structural analysis in this step showed the immediate learning outcomes, which led to the emergence of the following eleven themes: educational responsibilities, feedback from colleagues, decision-making, HFS, leadership, professional back-and-forth, psychological safety, situational awareness, task management, teaching and learning during work, and teamwork. The eleven themes shaped the ethnographic focus in the Transfer phase. See the example of the clinical phase's structural analysis in Paper II, Figure 5_B, p 9.

Transfer phase – The complete data set (RI-CEA)

The naïve reading of the entire data emphasised areas of consideration and experiences of an engaged QHP who was open to training and learning HFS and transferring the taught and trained into competency. Generally, there was an impression of positive interest in the project among the QHP and the organisations, and they expressed the importance of HFS. There was a growing expectation of the project's results and how it would change the clinical practice in all three phases. All emphasised HFS as crucial for patient safety. The QHP's constant demands of working, teaching and learning were observed. There arose a curiosity around the experiences of a lack of an HFS language and questions if HFS were more statements than an actual living language with underlying meaning and understanding. Additionally, curiosity arose around the responsibility and plan of transferring the newly taught and trained. Lack of time was often experienced and highlighted by the organisation and QHP. A dilemma between wanting to improve HFS and the experience of HFS not being requested or in focus among colleagues and organisation leads to doing as usual and a lack of effort to try.

Through the structural analysis and CEA, it became clear how the findings dealt with a complex clinical practice where the individual QHP solely had the total responsibility for the transfer process, along with the performance in a constantly changing clinical practice with a divided awareness between working (care for the patient and relatives), learning (new skills – HFS or technical) and teaching colleagues and students.

The figures below (Figures 11-12) depict how the study's results were derived from the selected data to the emergence of a theme. First, in the RIA figure, the *units of meaning* are presented in terms of 'what is observed/what is said' through *units of significance* in terms of 'what is it about'. Then, these 1st person perspectives (units of significance) are analysed through the CEA 3rd person perspective on the QHP real-time teamwork, varying from micro to macro lenses, between actions and reactions, activities and responses to these, and finally, the emergence of the themes.

Figure 11: Structural analysis based on data from the Transfer phase.

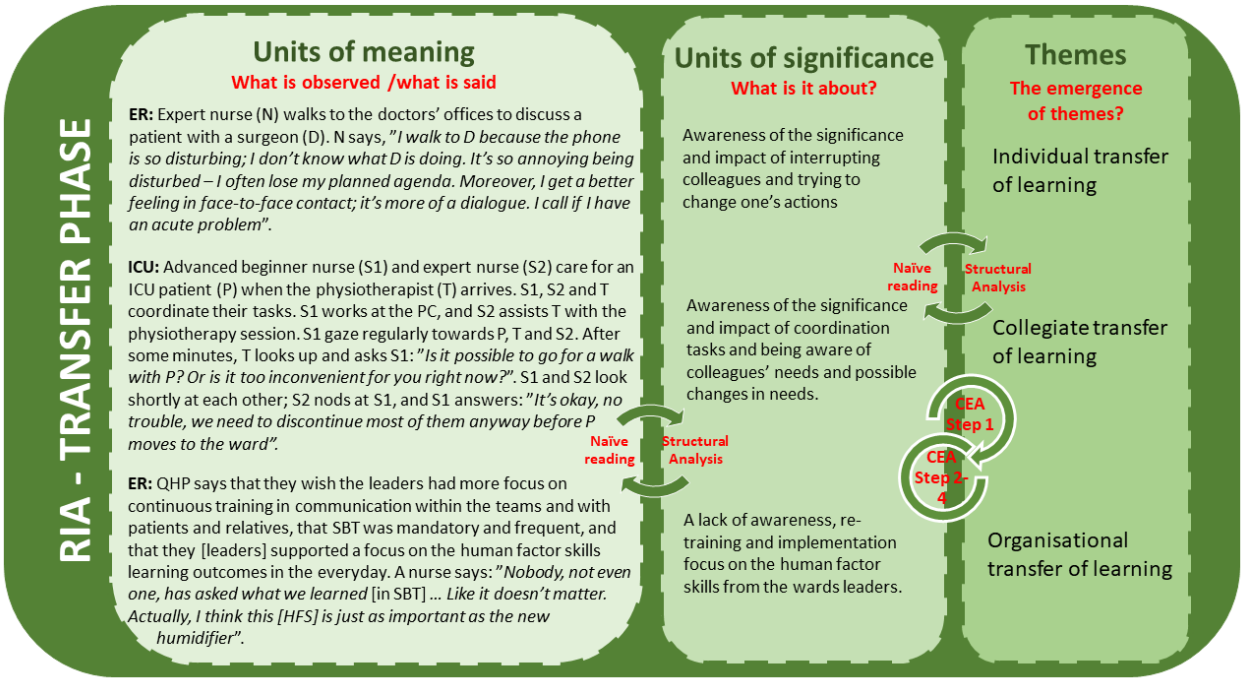


Figure 12: An example of Cognitive Event Analysis of a unit of significance.

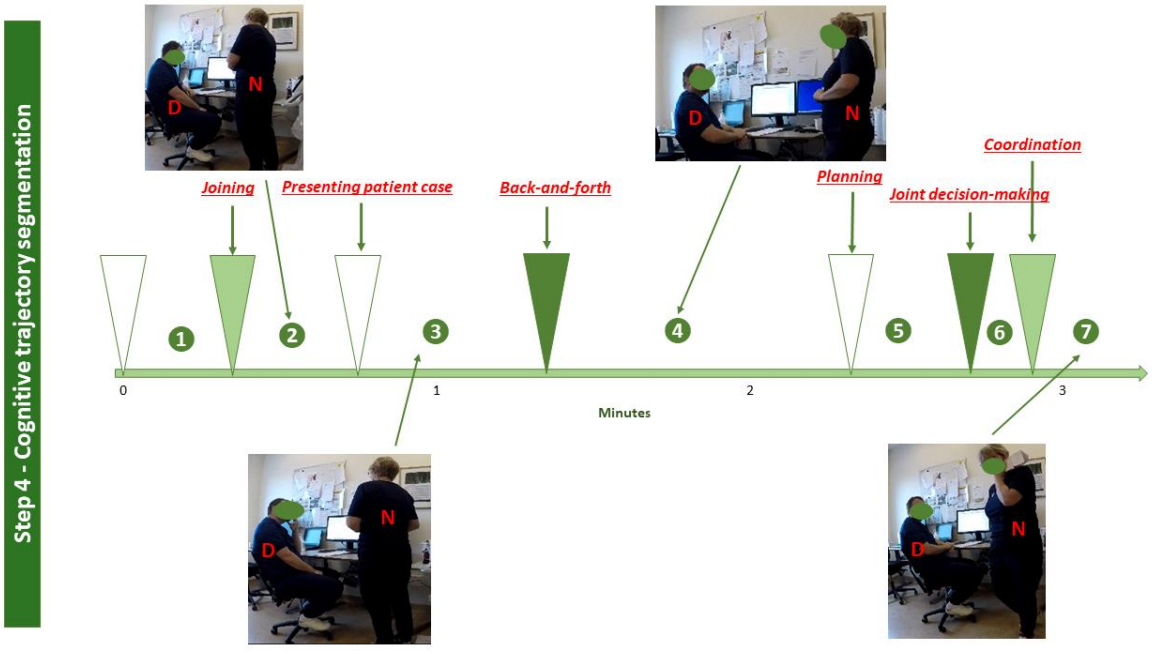
Figure 12_1: Demonstrates an example of the results in the CEA's five analytical steps for one unit of significance. Step 3, The Data Annotation, is expanded in Figure 12_2, and Step 4, the Cognitive trajectory segmentation, is unfolded in Figure 12_3 (Abildgren L; Lebahn-Hadidi).

CEA STEP	RESULT
1. Cognitive event identification	Two different cognitive events are identified First, D and N makes a joint decision Second, D and N has a peer-to-peer back-and-forth
2. Event pivot identification	Secondary event pivot: N enter the doctors' office, N need to discuss P's case, and coordinate the care plan Primary event pivot: Based on the discussion of the situation D and N make a plan and a treatment strategy
3. Data annotation	Examining shifts in D and N's behaviour (gaze, vocalisation and positioning) (see Figure **12_2**)
4. Cognitive trajectory segmentation	Mapping the event structure and the behavioural phase by splitting the situation up. Seven different phases are found in this situation, from the nurse entering the room until she leaves after their joint decision-making and coordination (①-⑦) (see Figure **12_3**)
5. Cognitive trajectory analysis	Three different human factor skills come into play in this situation: Situation awareness, teamwork and decision-making.

Figure 12$_2$: Demonstrates an example of the results in the CEA's data annotation.
The doctor (D) and nurse's (N) gaze, vocalisation, positioning and facial expression in the seven segments shown in the Cognitive trajectory segmentation (Figure 12$_3$) (Abildgren L; Lebahn-Hadidi).

Step 3 – Data annotation	Subject	Behaviour	① Arrive	② Joining	③ Case	④ Back-and-forth	⑤ Care plan	⑥ Decision-making	⑦ Coordination
	N	Gaze	D	D's paper	D	Room	D	D	Door
		Vocalisation	÷ vocal	+ vocal	+ vocal	+ vocal$_{back\text{-}and\text{-}forth}$	+ vocal	+ vocal $_{decision\ making}$	+ vocal
		Positioning	Stand Front$_D$	Stand Front$_D$	Stand Front$_D$	Stand Front$_D$	Stand Front$_D$	Turn away$_D$	Back$_D$
		Facial expression	Smile	Neutral	Neutral	Openness	Openness	Nodding$_{listening}$	Neutral
	D	Gaze	Screen	Paper	N	N	N	N	Screen
		Vocalisation	÷ vocal	÷ vocal	+ vocal$_{ask}$	+ vocal$_{back\text{-}and\text{-}forth}$	+ vocal	+ vocal $_{Decision\ making}$	+ vocal
		Positioning	Sit Screen	Sit Front$_N$	Sit Front$_N$	Sit Front$_N$	Sit Front$_N$	Sit Front$_N$	Sit Front$_{Screen}$
		Facial expression	Neutral	Smile	Aware	Openness	Openness	Neutral	Smile

Figure 12$_3$: Demonstrates an example of the results in the CEA's trajectory segmentation.
The video sequence is segmented into seven behavioural and functional phases, revealing that N interrupts D, not directly; N is standing smiling but silently in the doorway, waiting for D to notice her. When D becomes aware of N's presence, D looks at N. N, and D joins at D's desk. N presents the patient's case; both look at D's paper on the desk. D asks additional questions. D and N have a professional back-and-forth about different solutions and treatments. Hereafter, they plan the next step and make joint decision-making. D says, "If you do that, I will do this, and then we speak with the patient and her husband together?". N replies, "Yes, we agree; see you in 10 minutes". D nods and smiles. N turned around to leave the room, and D continued his previous task (Abildgren L; Lebahn-Hadidi).



Sub-study A and B

This section presents findings from my PhD partner's thesis (sub-study A and B) as these findings influenced the analyses of my PhD study.

Sub-study A – Rethinking the study of patient safety in healthcare organisations – investigated the complex work environment in healthcare and illustrated through an adverse event in a highly specialised medical ward. A nurse's mundane pill administration turns into complex decision-making about '*is it the right pill*' after the patient drops a pill to the floor. The complexity of a decision-making process and its reliance on QHP's micro-scale embodied coordination, engagement with the physical setting, and their expectation of other QHP's intentions are revealed in the analysis. The findings suggest that even safe medicine administration exposes nurses and patients to possible errors and contributes to patient safety studies by highlighting conflicting safety logic within safe medicine administration (Lebahn-Hadidi et al., 2021).

Sub-study B – Beyond *No Interruption Zones* in the medicine room: patient safety through human factor training – investigated an SBT intervention in the medicine room with the learning objective of safe medicine administration, coordination of tasks and situation awareness. The findings show that the nurses often have to break the "No Interruption Zone" rule of the medicine room to complete their tasks with high patient safety. Further, the findings suggest that nurses collaborate extensively in medicine rooms, including teaching (mentoring) novice or competent colleagues, although medicine administration is an individual task. SBT raised awareness, supported safe medicine administration, and showed that teamwork happens in the medicine room. The experienced nurse primarily takes the leadership role, guiding, teaching, mentoring colleagues, and shielding them from interruptions (Lebahn-Hadidi et al.).

Themes and Subthemes

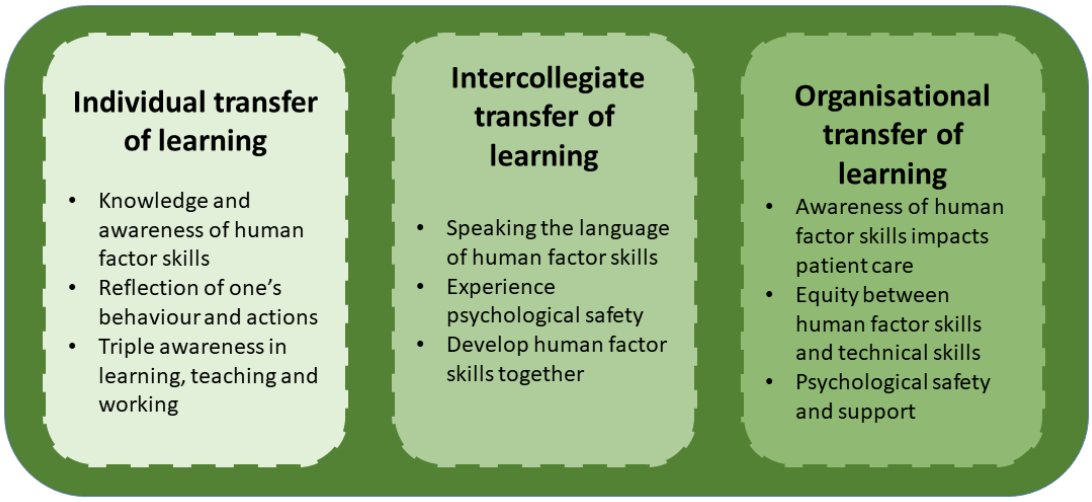
The following three key themes emerged through RI-CEA's systematic analysis:

1) Individual transfer of learning.
2) Intercollegiate transfer of learning.
3) Organisational transfer of learning.

Intercollegiate is the group of QHP working together. The organisation has more levels: local, institutional, regional, and national; however, in this study, the organisation is at the local (ward) or institutional (hospital) level, directly impacting the QHP and everyday clinical practice.

The themes have separate subthemes but are also mutually interdependent and intertwined and can not be seen as autonomous. The themes and associated subthemes are illustrated in Figure 13 and are elaborated on in Paper III.

Figure 13: The themes and subthemes that emerged through the Ricœur Inspired and Cognitive Event Analysis (RI-CEA).



The findings show that transfer of HFS after SBT is a process that happens to a limited extent on an individual and intercollegiate level in clinical practice. Nonetheless, transfer focus at the organisational level was not witnessed.

7. Discussion

This thesis is based on a qualitative study to develop knowledge on how qualified healthcare personnel transfer human factor skills taught and trained in simulation-based training to competency in clinical practice.

In this chapter, the main findings of this PhD study are discussed with selected research literature and theory to provide a nuanced and comprehensive understanding of the phenomenon transfer. The methodological considerations are discussed subsequently.

Transfer and implementation theories are expanding fast these years (Dohn, 2021, Dohn et al., 2020, Langford and Jain, 2023), not only within healthcare. This development supports the argument for exploring whether these induce an increased transfer and implementation of new skills trained in an SBT course. As mentioned in the background, research shows that training technical skills improves the learner's starting point for actions in clinical practice than without SBT (Andersen et al., 2015, Gustafsson et al., 2019, Nielsen et al., 2022). The findings of this PhD study suggest that this could also be valid for HFS.

The critical interpretation revealed a pattern "in front of the text" (Ricoeur, 1976), and this innovative process of understanding led to the development of the three levels of transfer to competency: an individual transfer level, an intercollegiate transfer level, and an organisational level of transfer. The discussion section will focus primarily on those three levels to develop new knowledge of transfer to competency. The discussion is divided into following four sections according to the findings:

- Individual transfer
- Intercollegiate transfer
- Organisational transfer
- How to transfer HFS from SBT to competency in clinical practice

Individual transfer

Findings show individual transfer of HFS to a limited extent four to six weeks after the intervention. The QHP expressed an experience of personal responsibility to transfer their newly taught and trained HFS to competency. Some QHP said they still worked with their individual transfer process and that the skills still needed to be transformed into competency. *"…it still hasn't become my second nature,"* as a nurse said in the Transfer phase. They had become conscious incompetent going towards conscious competent (Gordon and Burch, 1975) and thus, the participants moved the learned from the SBT context into the clinical context, resituated HFS to the clinical setting and in the process of implementing the skills (Dohn and Hachmann, 2020). As the ethnographic work was obtained four to six weeks after the intervention, it is unknown if the transfer process was completed and if the skills became a competency.

Knowledge and awareness of human factor skills

The findings revealed that the QHP had a sketchy knowledge and awareness of HFS. In the clinical and SBT phase, most participants articulated that they knew of ANTS (Flin et al., 2012), SBAR (Haig et al., 2006), closed-loop communication, etc. and previously had participated in training around CPR, TRAUMA, and likely acute scenarios. More participants expressed that they do not consider HFS equally crucial for the patient, only in acute critical situations, because "*… it needs to be high-speed*" (SBT phase). This supports the findings in the systematic review (Paper I) and the assumptions made in the introduction and background. This finding could substantiate that the healthcare system is (primarily) embedded in the biomedical and solution-oriented paradigm, where you repair what is broken (Murphy and Dingwall, 2007). Further, in the intervention phase, during debriefing, it became evident that the knowledge and awareness of HFS were insignificant, and the participants connected the use of HFS to acute and critical situations. The learning objectives solely focus on HFS, and the reflections around these skills' impact on patient care led the participants to choose HFS in everyday situations as a learning goal after the SBT as individual take-home assignments. This may be because acute specialities such as anaesthesiology, critical care and emergency training depend more on the team than within general medical specialities such as gerontology and neurology. Consequently, the SBT helped the QHP become aware of how HFS impacted their clinical practice, empowering them to try to transfer HFS. Mostly, when training in highly acute situations such as trauma, CPR, etc., the training of QHP is interprofessional. Nonetheless, the change in demographics and, consequently, an increasing number of complex, multimorbid patients create the demand for coherent and generic terminology (Flores-Sandoval et al., 2021).

Effectively transferring HFS from SBT to clinical practice competency requires individuals to be prepared to change their behaviour and routines. Dohn and Markauskaite state that individual competency development involves transfer, resituation, and transformation (Dohn and Markauskaite, 2019). In adult learning, the readiness to learn is crucial, involving the ability to apply new knowledge to social roles, augment existing experiences and problem-solving skills, create a sense of safety, and find meaningful connections between acquired skills and performance (Merriam and Baumgartner, 2020, Illeris and Ryan, 2020). This is evident in the data, particularly in areas such as the administration of interruptions, identified by participants as a critical HFS. Interruptions refract the workflow – a state of concentration and productivity. Interruptions impact the individual cognitive performance and initiate errors, time spent, and task complexity because of the personal requirement for time to shift from one task to another or to cope with an interruption (Altmann and Trafton, 2002, Puranik et al., 2021, Mark et al., 2008). When asking the QHP how they learned to cope with the multiple interruptions, the answers were similar: "*I learned it myself in the first year of practice*". After reflecting on this, QHP said that in the future, they would teach new colleagues different ways to cope. The consensus was that reducing interruptions can significantly enhance patient safety and contribute to the overall well-being of the QHP. Throughout the interpretation of data, it became evident that there was a mutual unspoken understanding that HFS was individual and that the responsibility of transfer was placed on the QHP.

The QHP expressed that they wanted to change, and after the intervention, they described seeing the potential to work with HFS, so they tried but often failed. They felt alone with the responsibility of transferring the newly taught and trained HFS skills; a competent nurse says: "*Nobody asks me how I'm doing, or helps me when it's hard … I'm on my own*" (Transfer phase). More QHPs said that after a while, they gave up and returned to the usual routines and behaviour. This emphasises that the transfer process is complex and demands motivation, empowerment and support. SBT, as a learning tool, incorporate both body and mind when teaching HFS to QHP.

Reflection on one's behaviour and actions

Moving from training and learning to competency, only 10-20% will try to transfer new knowledge to clinical practice themselves (Brinkerhoff, 2001). Individuals need to convince themselves that there are more pros than cons in changing their behaviour than arguments for a better way. Change is more about psychological factors than arguments (Rehman et al., 2021). The data showed that the QHP were capable of reflecting on their daily clinical practice and the trained scenarios; however, more participants expressed that although "*HFS makes sense, it's difficult if it is only me who try, and I don't know when to find the time to try again and again. My workday is already filled up*" (SBT phase). This is a challenge for the transfer process when the QHP feels overwhelmed with tasks and alone with the responsibility in a busy clinical practice everyday impacted by high personnel turnover. Furthermore, changing the QHP's way of working to integrate the newly taught and trained HFS requires courage, time and energy (May, 2013, Yamnill and McLean, 2001), and the QHP needs to be ready to challenge individual routines and behaviour and reflect on behaviour in action (Schoen, 1992). The readiness involves possessing awareness, knowledge, language, and understanding of HFS, engaging in reflective practices regarding individual behaviour and actions (Schoen, 1992), and effectively managing the triple awareness of learning, teaching, and working. Achieving this calls for a commitment to self-directed, lifelong learning (Bagnall, 2009) among the QHP – a process containing re-training and re-learning (unlearning) of existing competency. The concept of lifelong learning provides insight into how QHP strive to apply their daily work experiences to transfer learning from SBT to competency.

In the scenarios, the participants had hands-on experiences and were supposed to act and react adequately in an imitated clinical situation. Afterwards, in the debriefing, the participants should reflect on the individual and the QHP team's actions and reactions in the scenario. A competent doctor expressed that the debriefing gave her a new insight: "*In the situation, I had difficulties in linking with the nurses, as they were occupied with coordinating tasks, and didn't hear my prescriptions. I there I felt a need for more than medical knowledge*" (SBT phase). SBT should, according to learning theories (adult and transformative), improve the participants' extent of learning the taught subjects, as the participants are active in scenarios with their daily practice as the basis and reflect upon the situation with references to their everyday clinical practice (Herod, 2012, Merriam, 2017, Illeris, 2014, Schoen, 1992). Unlike lectures, which have separated the body and mind, SBT intertwines the use of body and mind (Bilon, 2019, Macedonia, 2019).

The most evident HFS transfer was the way QHP interrupted each other. The difference between the clinical and transfer phases showed increased awareness among the participants of how and when to interrupt each other. Drawing on adult learning theory, teaching and training should be meaningful for the adult, even considering integrating and transitioning new knowledge or skills (Merriam and Baumgartner, 2020). The awareness of the interruption's impact on patient safety, stress, etc., might result from the learning objectives in the SBT around interruptions (situation awareness). Data from the transfer phase showed how some QHP tried to change their routines around interruption, for instance, by talking to the doctor face-to-face instead of calling by phone. Nurse: "*I gather all the essential information [*prepare*] before I walk to the doctor's office and talk with him about the patient. Then, I can estimate if I interrupt him in other tasks*" (Transfer phase). More QHP did not interrupt colleagues working at the PC, in the medicine room or walking in the hallway before the colleague's embodied behaviour was assessed (see Paper III, fig. 6C p. 11). When a nurse expresses that she has become aware that her workday is one prolonged interruption, a prerequisite for her work, it makes more sense for her to try to change this. Meaningfulness in learning and the following transfer process are thus aligned with the learning theories (Herod, 2012, Merriam and Baumgartner, 2020). Furthermore, some of the expert QHP had seemingly developed a kind of interruption readiness, meaning that they were cognitively ready to be interrupted in most of their workday due to the awareness of interruptions as a prerequisite. However, this learning did not prevent the QHP from being interrupted by others. The individual QHP should, consequently, use energy to re-train and change routines (re-learn) the new HFS in their everyday, to support the transfer process (Dohn and Markauskaite, 2019). Nevertheless, it could be a bottom-up approach to change the interruption culture.

Triple awareness in learning, teaching and working

The findings revealed that QHP had a continuous triple awareness: caring for patients and relatives, teaching and introducing students or new colleagues, and learning (and transferring) new competencies. Further, their focus constantly changes, shifting between working, teaching and learning. This is a problem when the focus is on transfer of newly trained and taught skills, as there is a limit to how much information an individual can process simultaneously. The brain is created for peace to work and contemplate, concentrating on one thing at a time to avoid stress and cognitive overload. If the cognitive load is too high, learning cannot happen (Reedy, 2015). The triple awareness of caring, teaching, and learning impacted the transfer process, as the energy and mental focus were lacking. Yet, the QHP often focused more on transferring technical skills, which were more necessary for caring for the patient. As a nurse said: "*It's the patient I work for; I need to do my best for him to survive. So, I need to learn to use the new equipment ASAP and teach it to my new colleagues*" (Clinical phase). The question is if it is possible to implement HFS in the biomedical and economic paradigm where the QHP has a constant triple awareness, and the political and management focus is on performance and running costs. Research in embodied learning shows that higher cognitive functions such as HFS, memory, perception, feelings and language are represented in the brain's sensorimotor networks. Incorporating these via actions into teaching and transfer activities is a powerful tool supporting learning (Macedonia, 2019). Re-

training the newly trained HFS in clinical practice, the brain will improve the sensorimotor networks and the learning outcome based on the assumptions from embodied learning research.

Intercollegiate transfer

Intercollegiate transfer was revealed as another essential level in the transfer process. Intercollegiate transfer of HFS from SBT to competency in clinical practice happened to a limited extent. HFS are social skills used in interprofessional teamwork, also called team skills (Lee, 2018). Thus, a team approach in the transfer process is necessary. Observations and informal talks with participants revealed that QHP who had trained together also discussed how they worked with their HFS daily (Transfer phase). Further, the CEA microlenses discovered intercollegiate HFS transfer by comparing occasions in the transfer phase with similar clinical situations. For example, two nurses who underwent the SBT course demonstrated effective embodied hallway communication. In contrast, interactions with QHP who did not participate in the SBT course showed unreflective interruptions, mirroring Elkjaer's concept of learning as a social process involving actions and reflections (Elkjaer, 2022). Elaborating on this, Wenger emphasises that adult learning thrives in communities of practice (Wenger-Trayner et al., 2014). This aligns with the data indicating that course participants were more inclined to discuss the impact of HFS as their reflections in the debriefings. The work environment significantly influences the transfer process; a shared awareness among QHP and leaders is crucial. Recognising HFS integral to interactions is necessary among colleagues and in patient care, with the potential to reduce adverse events by enhancing QHP's HFS (Joyner, 2023, Nonaka et al., 2008).

Speaking the language of human factor skills

High quality of care can be achieved by viewing learning and transfer as an intercollegiate team process and articulating the behaviours as an adaptation to change greater understanding or improve team performance. This study implies that QHP predominantly engages in HFS reflections with colleagues who underwent the same course, possibly due to shared experiences, language and the psychological safety fostered within the course. The QHP experienced that the SBT kickstarted language development and skills to discuss HFS and intercollegiate reflections and discussions in the clinic. This corresponds to the statements that every developing process, inclusive learning, causes psychological changes and comprises a direct or indirect social interaction (Illeris, 2014) and that teamwork has an impact on the team performance regardless of the team or the task’s characteristics (Schmutz et al., 2019). Furthermore, the findings showed that SBT transformed the QHP’s knowledge from tacit to explicit by combining the discrete pieces of explicit knowledge to open reflective discussions of the tacit knowledge. This induced that the QHP articulated their HFS and gained new insights, which agree with other research results about team development (Nonaka et al., 2008, Buljac-Samardzic et al., 2020, Brazil et al., 2019). The SBT’s prompting of HFS and the following awareness signify the importance of social interaction in the learning and transfer process.

"It takes a village to raise a child" is an African proverb about sharing responsibility. Everyone has a role, and there's a place for everyone. Parents (and leaders) play a part, as do the neighbours (organisation) who help with babysitting and with tips for childcare. In healthcare, the quality of care, education, and transfer are also joint responsibilities. It takes a multidisciplinary team and organisational support to cure a patient and to transfer HFS into competency. It is not enough that a few QHPs have sufficient HFS because every QHP has a role in the team and patient care. The participants expressed feeling alone with the responsibility of transferring these newly taught and trained HFS into intercollegiate teamwork; they felt inadequate and unmotivated. A nurse says: "*I tried to change … but when nobody demands or talks about these HFS … then I just give up. Give up trying. I've got so many tasks every day*" (Transfer phase). The transfer process is, seemingly, viewed as an individual task, like with technical skills. As HFS are a team skill, the transfer process should focus on the whole team competency of HFS by re-training, re-learning, experimenting and reflecting in action (Schoen, 1992, Dohn and Markauskaite, 2019, Illeris, 2014). Integrating a team view in the transfer process could improve the readiness and motivation of each individual to contribute to the transition of the HFS. When the expectancy, conditions, and goals are incomprehensible or invisible to the QHP, they lose their motivation and belief in the transfer process (Yamnill and McLean, 2001), and the transfer of HFS will fail.

In the Transfer phase, findings showed that the QHPs who participated in the SBT discussed their HFS with those they were trained with. In this way, they developed a joint language around HFS and tried experimenting with their previous practice by reflecting on it with a colleague. Yet, this was only seen to a limited extent due to the same reasons mentioned in the individual transfer. Developing team skills demands team development, relations, and courage to change and give and receive feedback among colleagues (Andreatta, 2010).

Experience psychological safety

A transfer process demands, as mentioned, that the QHP are courageous, ready to learn, change their routines, habits and behaviour and motivated; consequently, the didactic considerations are essential before the process begins. An interesting finding was that the QHP only reflects and discusses HFS with those they trained with. This highlights the requirement for psychological safety to transfer HFS to team competency. More participants stated that talking about HFS with whom they felt safe could share the awareness and insights the training added was more accessible. They needed to feel safe in the work environment. They said: "*It improves how we work together in the clinic*", "*It's easier to go to or ask doctor X with a problem, lack of knowledge or miscommunication after we trained together. I feel safer. It's okay to ask".* This resonates with Edmonson's emphasis on psychological safety for organisational development (Edmondson et al., 2016) and creating an environment conducive to constructive peer feedback (Rosenthal et al., 2020, Clay et al., 2007) on behaviour and HFS. Feeling safe in the workplace is about being comfortable being and expressing oneself. Psychological safety is "The degree to which people view the environment as conducive to interpersonally risky behaviours like speaking up or asking for help" (Edmondson et al., 2016 ,p71).

The feeling of psychological safety in the workplace affects the QHP's well-being and behaviours related to learning, too. Suppose the QHP does not feel safe in the workplace due to, e.g. hierarchy, ability threats, ruling by fear, competitive environment, etc. In that case, it can be challenging to learn, re-train newly taught skills and transfer them to competency. Perhaps even more when it is HFS, which are social and cognitive skills developed and improved in intercollegiate interactions. Without psychological safety, the QHP will not seek feedback or re-train newly taught HFS in clinical practice (Edmondson, 1999, Edmondson et al., 2016). Maybe this explains why the QHP only spoke with the colleagues they participated in the course. In SBT, the psychological safety issue has been a key concern for many years, and the SBT theory stresses it as a demand; thus, it is explicated and imposed as a condition to learn in every course (Cheng et al., 2017b). The SBT intervention created, due to the theoretical foundation, an environment of psychological safety in which they could reflect on their SBT practice and refer to their everyday. This might have allowed them to continue these reflections in the clinic. Unfortunately, demanding and creating a psychologically safe environment is not a custom in the clinic (Edmondson et al., 2016).

The necessity for psychological safety is, thus, essential during SBT and in the transfer phase. Each QHP team relies on and benefits from each other in teamwork. This requires openness, trust, integrity and mutuality, which impacts the quality of care (Gum et al., 2010). Social relations are contagious – good or bad. The successful transfer of HFS depends upon the dynamics of intercollegiate relationships and interactions. This transfer hinges on the willingness of personnel to adapt to the collaborative work culture (i.e., the ward's culture) and the level of psychological safety within the organisation (Dohn and Markauskaite, 2019). The study's findings suggest observable behavioural changes in intercollegiate HFS following the SBT course. Conversely, these changes are noticeable mainly in connection with fellow participants from the SBT course.

Develop human factor skills together

HFS demand individual and team learning and, thus, are relevant to improving teams. For instance, intercollegiate communication is an HFS and is one of the most important tools in teamwork. However, breakdowns in communication are identified as frequent causes of adverse events (Joyner, 2023). The findings of this study show that SBT helped QHP become aware of the HFS's impact on their everyday work and teamwork. The QHP expressed that the debriefings opened an awareness of HFS and their impact on the performance in clinical practice. The participants said they knew the importance of HFS, but the SBT, focusing solely on these skills, made them aware on another level. A nurse said: "*The other times I have participated in SBT, it has been something acute. CPR, tension pneumothorax or … you know. Always acute. In the debriefings, we talked a little about leadership. But the doctors are always in focus, not the team. Like we [other QHP], it doesn't matter. Mostly, we talk about the patient case, not the HFS*" (SBT phase). This quote about acute SBT and the focus on the leaders' performance correlates with findings in the systematic review (Substudy 1). The quote emphasises that HFS are rarely formally taught; when taught, it is primarily along with technical skills that often outshine HFS (Abildgren et al., 2022). Nevertheless,

teamwork is present in every situation with two or more personnel, happens close to the patient and relatives and is the backbone of the modern healthcare system. QHP is in a constant teamwork setting, and the teamwork happens not only around the patient. However, unlike this project's findings, most SBT teamwork training is about what happens directly around the patient (Buljac-Samardzic et al., 2010, Lapierre et al., 2020).

Observing the QHP's teamwork, HFS was used in every 'meeting' of the workday, not only in CPR, trauma and other acute critical situations. This study's ethnographic data suggests three types of teamwork. Close teamwork is used when multiple personnel work together around the patient, sometimes unknown to each other. Then there is teamwork away from the patient when colleagues are planning and coordinating tasks around the patient care; it could be planning a conversation with the patient and relatives, maybe about breaking bad news, coordinating mobilisation (how and when) of a patient with the physiotherapist, or the nurse and doctor discuss what is essential to address in the round. Finally, there is teamwork across wards or sectors, where the QHP hands over the patient's case, situation, and needs, present and future. This means that when a ward wants to train and improve their QHP's HFS, it is necessary to train all three types of teamwork in clinical practice. As mentioned, most of the daily work is routine, and by training these frequently, the QHP learn that HFS are a kind of generic skills used in every team situation. Accordingly, the QHP develops an HFS language and may increase the motivation to transfer their HFS, as it becomes more meaningful as required in adult learning (Merriam and Baumgartner, 2020, Herod, 2012).

Training QHP teams are often compared with training the Cockpit team in aviation or the pitstop crew in Formel 1 races; however, this comparison does not hold. QHP teams usually have dynamically changing members or are brought together ad hoc, e.g., the size varies among diverse situations and unique patients, often within minutes (Manser et al., 2009). The individual QHPs do not always have the same setting (cockpit, pit), role (captain, co-pilot), task (pitstop crew), or patient situation (aircraft or car). It depends on the day, situation (acute or routine), patient, etc.; thus, it is impossible for QHPs to train to perfection for a single task, role, or situation. Nevertheless, as substudy 1 (systematic review) shows, HFS can be trained and improved through SBT (Abildgren et al., 2022); a doctor says: "*The sole focus on HFS meant that I could not hide behind my medical knowledge and competencies. I had to reflect on my behaviour and how it affected the whole team*" (SBT phase); and in both the SBT and Transfer phase participants narrated about the positive effect of training together interprofessional, and changes was seen as shown in the example from Paper II where two nurses meet in the hallway. "*A possible interpretation is that the meeting in the hallway allows N1 to ask for help with a tiny smile. N2's action of slowing down her speed could be her reaction to N1's smile and nod and signal to N1; You can interrupt me.*" (Abildgren et al., 2023 p8). This shows that SBT improves QHP's awareness of HFS, refines HFS competencies, and increases patient safety; SBT also increases the intercollegiate relationship across professions outside SBT.

Training interdisciplinary QHP teams can improve the quality of care by introducing HFS as a generic collaborative tool; accordingly, increased focus on the transfer process is necessary. Further, this is supported by the research around IPE (Lee et al., 2021).

The intercollegiate transfer of HFS is intricately linked with individual transfer, and vice versa; effective transfer can only occur in intercollegiate collaboration. This study underscores the importance of continuous focus on teamwork, not just in highly acute situations.

Organisational transfer

Organisational transfer was revealed as the third essential level in the transfer process, as transfer of HFS required an organisational awareness and focus to succeed. However, the findings suggested, on behalf of the QHP's experiences, that demands were missing from the leaders after participating in the SBT course. The lack of attention and contribution in the transfer process led to the QHP's loss of motivation and energy in the transfer process. One can wonder why hospitals neglect the transfer and internalising of HFS when they use billions of Euros yearly in courses and education (Tolsgaard et al., 2015). The reasons can be multiple. The hospital's daily flow and operation are the organisation's key focus, but competent QHP and high-quality care are also mandatory. This is evident in i.a. the Danish government's health reform presented in 2022 (Sundhedsministeriet and Regeringen, 2022) and a governmental press conference on March 23rd, 2023 (Statsministeriet, 2023), where new initiatives to increase the quality of healthcare are presented along with new demands to the QHP's competence levels and tasks. Due to a highly complex and pressed everyday, the QHP makes complex trade-off decisions to manage the pressure between competing priorities (Sanford et al., 2022). Understanding these trade-off decisions (i.e., the constant triple awareness) and their consequences is vital in HFS's transfer process. Another reason could be that transfer is viewed as an individual task and responsibility innated in everyday work. Yamnill and McLean state, "*Learning is of little value to organisations unless it is transferred in some way to performance*" (Yamnill and McLean, 2001, p196).

Awareness of human factor skills impact on patient care

Organisational engagement in the transfer process is essential if the QHP must transfer newly trained HFS. The organisational task in the transfer process can be seen as an umbrella above and a safety net beneath, supporting and protecting the individual and collegiate transfer. The workplace ought to be one where the QHP can share their knowledge for the transfer process to be successful. This means sharing concerns, questions, mistakes and half-formed ideas (Edmondson et al., 2016). The data showed that it was possible to create a space of psychological safety in the SBT where the QHP dared to reflect and discuss HFS, the present practice and how their wished practice was in the clinic. This indicates that it might be possible to create a similar psychological safety space in the clinical as well; still, it calls for the organisation to make it explicit and necessary in the work environment.

In addition, transfer requires, as mentioned, psychological safety, courage, and energy and cannot be managed by one person (leader or associate) alone; it takes a team of, e.g. HFS ambassadors, a change-friendly environment, and improved conditions for transfer. Psychological safety (Edmondson et al., 2016), compassion (Jazaieri et al., 2013), safe space policy, buddy system and a peer feedback culture (Rosenthal et al., 2020, Tucker et al., 2002) etc. are some activities the organisation can work with to improve the psychological safety in the ward. Research in psychology, organisational and implementation theory has shown that implementing new initiatives in a complex clinical everyday is difficult because of the many dimensions of change required (Tucker et al., 2002, Tucker and Spear, 2006, Kristensen et al., 2016). Looking back at the vast changes in healthcare during the COVID-19 pandemic, QHP and organisation changes (local, national, and global) happened. Also, people, in general, implemented changes from day to day, helping each other to find ways to cope with the situation (Juelsgaard et al., 2022, Rodríguez and Hignett, 2021, Catchpole et al., 2020). This shows that when all three levels interact, the transfer process improves. Thus, the organisation should take the lead in the culture change by gaining awareness of HFS, joining the development of the language of HFS, establishing equality between HFS and technical skills and adjusting the approach from solely individual transfer to integrating intercollegiate and organisational activities in the transfer process.

A significant problem is interprofessional communication. There is, per se, professional terminology, but looking closer, it becomes evident that the mutual professional terminology is often reduced to medical language. Clarity around team terminologies is needed due to inconsistent definitions, misuse of terms and interchangeable use of similar terms (Martin et al., 2022, Flores-Sandoval et al., 2021). Each profession uses and develops its own intraprofessional terminology, maybe due to silo education; this represents a server problem and basis for errors within different healthcare professions. However, it is more than just a problem within the team terminology. There needs to be more clarity on joint technical terminology and knowledge of co-healthcare professionals' competencies and responsibilities in clinical practice. The ethnographic data indicates that new QHPs from different professions did not have a common vocabulary or know their interprofessional team members' competencies and responsibilities. Accordingly, new QHPs must learn the terminology and adapt in their first years of work in healthcare while learning to become a nurse or a doctor, maintain care and safety for the patient and relatives, etc. Knowing the local clinical practice’s terminology is essential for teamwork and the patient’s safety and cure. IPE, pre- and postgraduate, could be a way to minimise the practical chock that newly educated QHP experiences (Cory et al., 2020, Wong et al., 2016)

Obtain equity between human factor skills and technical skills

Transferring newly taught and trained skills is in constant competition with the QHP’s other tasks – the triple awareness challenges (learn, teach, work) – which force the QHP to make trade-off decisions to cope in the clinical everyday (Sanford et al., 2022). This awareness should be integrated into the organisation's plan for supporting the transfer process. The organisations

participating in this PhD project expressed expectations, engagement, involvement, goals and leadership to motivate the QHP to meet the requirements. Moreover, after the intervention, the leaders received a document with information about the taught and trained HFS, attention points regarding HFS in the local ward and recommendations to which HFS the participants had highlighted as important to implement (see Appendix 3). Nonetheless, the analysis showed that the organisational focus on creating transfer was invisible to the participants. A nurse said, "*No one asked me what I've learnt or need to implement … I'm on my own*." Another nurse said: "*Sometimes the heads [leaders] underline the importance of SBAR and Closed-loop during clinical meetings. Still, it's my responsibility to know how to change my routines, request it from my colleagues and teach it to the new ones*." (Transfer phase) (Abildgren L; Lebahn-Hadidi). These quotes demonstrate the absence of awareness of focus on the transfer process after a course. The organisation seems to lack an awareness of HFS, similar to the QHP during the intervention. Transfer needs an organisational responsibility of the internalisation from the training to competency in clinical practice.

Healthcare is constantly changing; new and improved equipment, procedures, technology, and treatments, the altering process never ends. Nevertheless, as shown in the SHELL model in Chapter 4 p.20, every part impacts the other factors (Hawkins, 2017). The data showed that the wards focused on implementing new equipment in the Transfer phase, whereas the HFS was deprioritised. By focusing mainly on the hardware, software and environment, the lifeware gets lost and might increase the risk of demotivating the QHP, their stress levels, resignation, frustrations, dehumanisation of the patients and flight from the professions. In some wards, the experts are not actually experts; they are only advanced beginners or competent because the expert QHP moves to other wards and departments or even leaves the profession (Boniol et al., 2022). The present global healthcare situation with high personnel flow could indicate this tendency.

Psychological safety and support of the personnel

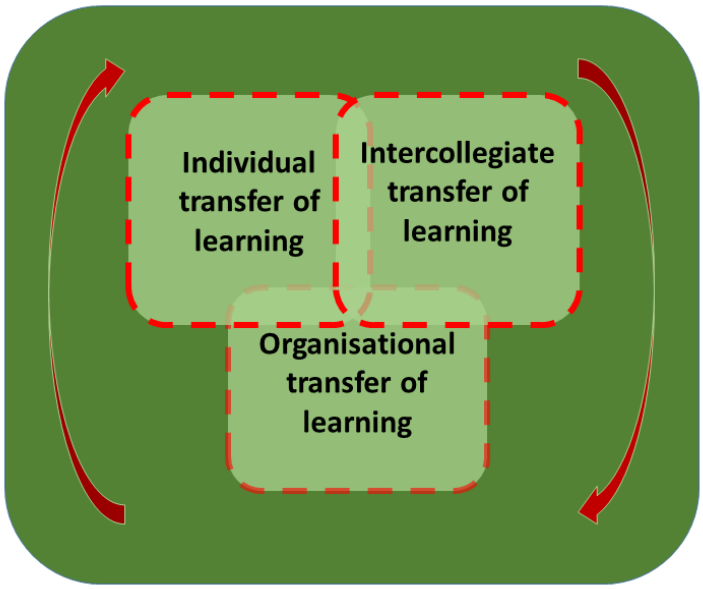
This study's findings stress the necessity for heightened attention to organisational responsibility to establish transfer. In the examined wards, neither QHP re-trained nor transferred the newly acquired HFS to competency following the course. However, the organisations' attention remained on transferring technical skills. Nonaka's research supports that technical skills may be perceived as more valuable or accessible than HFS. Nonaka emphasises the social nature of learning and transfer, where tacit knowledge is internalised through explicit sharing within an organisation (Nonaka et al., 2008). Unlike technical skills, which are primarily individually acquired, HFS necessitate a social and collaborative approach and processes, demanding organisational focus and transfer for success (Dieckmann et al., 2020). In contrast to technical skills, HFS cannot be algorithmically defined without making them technical; neither can HFS be categorised as right or wrong since HFS involves handling unique situations. Conversely, reflective consideration within the intercollegiate and the organisation could enhance the transfer and retention of HFS by embedding individual HFS within the competency of the intercollegiate and scaffolding them through organisational support (Bandura, 1991, Farr, 2012). Without an organisational focus on

the transfer process, transfer remains individual, and retention is short-term. As shown with the citations above, the participants noted that the lack of organisational emphasis led to challenges in behaviour change, and they reverted to their familiar patterns despite some lasting individual skills. A doctor highlighted in the Transfer phase that individual efforts without organisational support are futile, leading to the eventual abandonment of change efforts. Organisations should, thus, recognise the impact of transferring newly taught and trained HFS on care and treatments. The participants' perspectives varied; some viewed HFS as a crucial skill, and others viewed HFS as only essential in acute situations. The analysis suggested that HFS, while embedded in the individual's personality, can be trained when explicated, reflected upon, and made transferable. Leaders and psychological safety are crucial in supporting, motivating and embracing QHP in structuring the transfer process and avoiding a mere checkbox approach to course completion. Understand that patient safety is a collaborative accomplishment (Pedersen and Mesman, 2021). It is not the individual QHP alone that ought to change; it is the culture in the whole organisation (local and institutional).

How to transfer human factor skills from simulation-based training to competency in clinical practice

This study's findings emphasise the importance of involving all three levels (individual, intercollegiate, and organisational) in transferring and implementing new knowledge, skills or equipment. The process should integrate the individual, intercollegiate, and organisational levels to transfer effectively. As illustrated in Figure 14, the levels are intertwined, interrelated and interdependent. The individual QHP should be prepared to learn, reflect on their actions, and strive to modify their behaviour. Similarly, intercollegiate collaboration is essential to articulate and make HFS explicit, speak and be aware of HFS and its impact on clinical practice and facilitate constructive feedback. QHP are each other's prerequisite in patient care, and a feedback culture in a ward can be seen as a strategic intervention in the transfer process. The organisation must support, motivate and lead the way to achieve this. The transition from SBT to competency, thus, relies on three intercorrelated levels: individual, intercollegiate, and organisational. This aligns with existing research on learning transfer, internalisation, and the retention of new skills (Dieckmann et al., 2007, Issenberg et al., 2005, Tolsgaard et al., 2015, Sanford et al., 2022, Boniol et al., 2022). It is important to note that the transfer and retention of HFS differ from knowledge transfer, as knowledge is not the same as embodied competency. The data suggested that HFS can be taught and learned, yet they are also ingrained in an individual's personality, influenced by personal history, culture, and characteristics.

Figure 14: Human factor skills transfer model showing how the three levels are intercorrelated, intertwined and interdependent.



There is no easy way to improve QHP's HFS and patient safety problems. This study showed a way to enhance QHP's HFS in clinical practice; however, further research is necessary to establish if it increases patient safety. It takes 66 days, on average, to change behaviour if you are motivated, have the energy and get support (Gardner et al., 2012). Adding the QHP's constant triple awareness, shiftwork and, high emotional demands (life-death-trauma), empathical load, it is not surprising that transfer of HFS, higher cognitive functions, is comprimised. Two of the most challenging things in organisations are implementing new behaviour and changing the culture (Alvesson and Sveningsson, 2015), and transferring HFS from SBT to competency contains both implementation and culture changes. Learning happens through a mixture of the stimulus of the surroundings and the individual response; the greater the distance between action and result, the greater dependence the learner has on other cognitive mechanisms, e.g. memory, motivation, language and perceptions (Illeris, 2014, Illeris and Ryan, 2020). Moreover, the findings showed that HFS is still viewed as an essential but embedded skill concerning everyday situations.

Moving from learning to competency

Moving from learning to competency, as mentioned, only 10-20% will try to transfer the new knowledge to clinical practice themselves; the rest ought to be supported, motivated and empowered. What happens before and after a course has more impact than what actually occurs during the course. Transfer happens when there is a sense of accountability and expectations (Brinkerhoff, 2001, Chamberland et al., 2018). The findings implied that the most critical challenges in transformation are behaviour change, corporate culture, underestimation of complexity, and lack of commitment from higher management. The small things – the soft values and HFS – are often underestimated (May, 2013, Langford and Jain, 2023). Therefore, the most crucial thing in the transfer process is that the organisation actively supports the QHP and focuses on transferring

the newly taught and trained skills. This could be done by planning a freeze period from other changes. The goal is to achieve time to re-train, re-learn, and optimise the conditions for the wanted skills, behaviour or structures to become competency among the QHP (Cummings et al., 2016). High performance claims a mindset, performance, and culture of excellence; good intentions are rarely enough.

The role of the organisation

The organisation plays a vital role by motivating, supporting and framing the transfer process for the individuals and intercollegiate teams and creating a work milieu where the QHP experiences psychological safety. Besides recognition and success, motivation includes salary and supervision (Herzberg et al., 1959, Jones and Lloyd, 2005). This PhD study found that transfer of HFS deviates from transfer of technical skills, as it was not only an individual task of transforming and integrating the skills; it required individual, intercollegiate and organisational focus. In the organisational transfer process, the relationship between individual, intercollegiate and organisation was interactive and intertwined. The three parts exist separately, yet they are interdependent on one another and influence each other. Nonetheless, as mentioned above, the organisational focus was often on technical skills. When training HFS only in acute settings, there is a risk that participants equate HFS as a skill you use only in acute and critical situations. The findings suggested that training HFS in everyday situations could result in a higher degree of transfer because the QHP train this in daily situations, not only in particular situations. Transferring human factor skills to competency involves translating and integrating the skills and expertise into automated embodied systems of understanding human capabilities, limitations, and behaviours (Elkjaer, 2022). Just like Tai Chi, an internal Chinese martial art practised for defence training, where you train slow and controlled movements, and when you master these movements, you can increase the speed. The frame, support, and context are essential for QHP in a transfer process, and the organisation ought to take the lead, guiding individuals and teams and actively empowering and supporting both individual and intercollegiate transfer processes for successful implementation.

Nonaka views a company (a ward or an institution) as a living organism, not a machine. Everything impacts the rest of the organism and is a non-stop process of personal and organisational self-renewal (Nonaka et al., 2008). Accordingly, if a ward wants to improve the QHP's HFS, the organisation needs to change the transfer approach from an individual-responsibility transfer focus to an organisational-responsibility team-focused transfer. Cultural changes are slow and complex; however, if they succeed, the impact is long-term (Yamnill and McLean, 2001). The organisation ought to have a plan where the QHP feels involved, equity, and as a part of the solution. A bottom-up and top-down model, answering questions such as: How do we work with HFS in this ward? What are our goals and baseline? How do we train these skills and transfer the new skills to competency? Which behaviour and actions do we want to see in the everyday? To change the day-to-day running of an organisation, focusing on learning by working with its culture of continuous improvement, experimentation, and learning (Senge, 1990, Caldwell, 2012,

Edmondson et al., 2016). To transfer, there is a necessity to stretch more than just time and individual responsibility; a multi-dimensional approach, time to reflect, try, and apply feedback, relationship, space, tools, structure, time, and clinical practice goals are necessary. Peer feedback can be a solid tool in internalising HFS.

To sum up, the transfer of HFS to competency in clinical practice was only reached to a limited extent. Nevertheless, this PhD study developed new knowledge on "how" transfer happened and showed that the responsibility of transfer often lies at the individual and intercollegiate levels due to understanding skills transfer as an individual process. The interpretation and discussion showed that all three levels (individual, intercollegiate, and organisational) were necessary to transfer HFS to competency, as the three levels are interdependent and intertwined. A transfer process should, therefore, incorporate and emphasise the wanted performance, a visible and comprehensible goal, a healthy and psychological safety climate, motivation and support and peer feedback - not just a learning intervention.

Methodological Considerations

This section discusses this PhD study's methodological considerations and limitations regarding the methods, data collection, analysis and findings, including validity, reliability, transferability, trustworthiness and limitations. In qualitative research, trustworthiness should be considered at all stages of the scientific process. The concepts of validity, reliability, and transferability refer to integrity, precision, application of methods in the research, consistency within the analytical process and to which extent the study can be transferred to other settings (Malterud, 2001, Morse et al., 2002).

Systematic review

The systematic review (Paper I) provided a comprehensive pre-understanding of the research on SBT on HFS. It revealed the extent of the research gap around transfer of HFS to competency in clinical practice. This pre-understanding was tested during the ethnographic studies.

The strength of a systematic review is that the individual studies, not in themselves, are insufficient to impact practice; conversely, when they are assimilated and interpreted, they make it possible to influence the evidence base (Grant and Booth, 2009). The systematic review included in this thesis explored the effectiveness of training QHP's HFS through simulation-based education and revealed new areas of interest and scientific gaps. The systematic review, thus, became not only a pre-understanding of the field around SBT of HFS but also an argument for the overall research question of how transfer of knowledge and skills becomes competency in clinical practice. The golden rule of a maximum of one year from search to publication (Cooper et al., 2018) meant that it was necessary to update and re-interpret the results before Paper I could be submitted to the journal. Two new studies were applied, and their results did not deviate from the prior results, nor did they add new knowledge.

The search strategy comprised two blocks, although the SPICE model has five blocks (Booth, 2006). The search strategy was developed and qualified by a research information specialist, and it was decided to exclude a search on adverse events, safety management, and patient safety to avoid too many false positive hits. Despite the qualification of the search strategy, the number of hits in the final search was 34,846, and it contained many false positives, e.g., simulations in powerplants, the development of HFS assessment tools, and communication with patients. Due to, i.e., the use of different assessment tools – the inappropriateness of combining 'apples and oranges' (Grant and Booth, 2009) – a meta-synthesis of the data was not possible, and a more precise result of the effectiveness was, consequently, not achievable.

Unexpectedly, individual HFS (e.g. communication, teamwork, or leadership) was often an add-on part of many studies of SBT and was frequently only mentioned with few words in the results or measured quantitatively by numbers, time, etc. The large number of newly developed HFS assessment tools in the search results could be an attempt to quantify or technify the assessment of HFS to a more assessable technical skill (e.g. ABCDE, ISBAR).

The validity of the systematic review is considered high (Jadad et al., 1998), as this study's research question and inclusion criteria were well-defined and clearly articulated, a review protocol considering all the relevant perspectives and phases was created before the search, multiple established research databases were searched, well-known electronic programs were used, and three researchers performed the screening and inclusion of studies. Although the validity is considered high, it is lowered because only one author thoroughly read and fully assessed the included studies, which introduces the potential for selection bias. To mitigate this, any uncertainties regarding selected studies were discussed within the broader author group. However, using human coders in content analysis unavoidably affects intercoder reliability, as noted in prior literature (O'Connor and Joffe, 2020). Further, the multiple incomparable methods to measure the effect made a meta-synthesis impossible. The reliability of the systematic review is considered high as saturation was attained with the inclusion of grey literature and multiple databases. Because the updated search did not apply new results, more researchers saw the same things in the analysis. The findings were discussed and reflected upon during the interpretation process, and it is plausible that a repeated study will generate similar findings. Moreover, the finding in this systematic review correlates with findings in minor discipline-specific reviews in the field (Boet et al., 2018, Buljac-Samardzic et al., 2020, Gjeraa et al., 2014). Additionally, 20 of the included studies were conducted in emergency medicine settings, potentially influencing the generalisability and transferability of the findings. An additional, comprehensive review encompassing various settings could provide a broader perspective. Lastly, the potential impact of publication bias should be acknowledged, as studies with unfavourable results regarding SBT may have yet to be published (Brassey J et al., 2017). This could twist the overall analysis in favour of positive outcomes.

Ethnography

The ethnographic study provided a nuanced description and insight into the complex clinical practice for QHP and opened the transfer phenomenon. The insight revealed the nature of how newly taught and trained HFS are transferred, and the suggested a team focus on transfer rather than the prevalent individual focus on the transfer process when HFS should become a competency. The SimLEARN collaboration between social and health science was a strength; this unity provided an inside and an outside perspective on data and increased the external and internal validity. This will be elaborated on in this section.

Methodological. The congruity between the chosen philosophical approach of phenomenological-hermeneutic and the methodological approach of ethnography is suitable, as is the congruity between the methodology and the research questions. The methodological approach enables the highlighting of the interpretations of the transfer simultaneously while considering transfer in terms of the participants, their cultural backgrounds and everyday experiences. Doing ethnography provided a nuanced understanding of culture, community, or context that could

come only from personal experience (Hammersley and Atkinson, 2019). It helped answer this PhD study's descriptive research questions about transfer to competency.

As QHP's HFS are immeasurable, embodied, discrete, tacit and sometimes invisible, the phenomenon of transfer benefits from an ethnographic method to gain a nuanced insight. On the other hand, ethnographers become a part of the settings in which data are collected; thus, an impact on data and research is unavoidable (Hammersley and Atkinson, 2019). The relationship with the QHP developed during the data collection period, as the QHP got to know me, and I became some kind of member of the wards. This can influence the data; however, I noticed that the relationship also became more informal and collegial, where I shared some of my experiences and everyday practice. The QHP opened for more personal and honest talks with some degree of give-and-take. Nonetheless, by explicating my pre-understanding before the data collection began, the theoretical framework (See figure 3, p18) and my ethical considerations about my role (See p39), it was possible to re-distanciate myself from the situations, as the video recordings had left the reality and become a 'text' that has left the intention of the author (observer) (Ricoeur, 2016). Through the PhD project, my understanding also went through the helix of the phenomenological-hermeneutic process, and my complete understanding of the phenomenon has developed.

RI-CEA. The development of a hybrid method consisting of a phenomenological-hermeneutical approach inspired by Ricœur's theory of interpretation and Cognitive Event Analysis originated from cognitive ethnography made it possible to open and interpret both a 1st and 3rd person perspective on QHP's HFS competency before, during, and after SBT. This interpretation builds upon natural, human and social sciences and a broad foundation of theories about, e.g. patient safety, adult learning, didactics and transfer. This landscape delves into phenomenological-hermeneutics, Ricœur, Ethnography, and Cognitive Event Analysis, exploring diverse methodological approaches. While each method offers unique insights, they share a common goal of understanding phenomena. Phenomenological-hermeneutics delves into subjective interpretations, Ricœur adds a narrative dimension, Ethnography immerses in cultural contexts, and Cognitive Event Analysis scrutinises mental processes. Despite their diverse paths, these methods share a common goal: unveiling the layers of meaning within the complexities of human existence. Moreover, phenomenological-hermeneutics and Ricœur emphasise interpretative frameworks, whereas ethnography engages in cultural settings. Cognitive Event Analysis focuses on mental processes. Recognising similarities and differences among these methods enriches the understanding of varied research perspectives. Some of the key similarities between the philosophical and methodological approaches are the emphasis on interpretation, role of language, social and temporal dimensions, focus on subjectivity, understanding the self and integration of multiple perspectives (Ricoeur, 1976, Ricoeur, 1999, Cowley et al., 2017, Cowley, 2011). Nonetheless, despite their shared interest in understanding the complexities of human experience, interpretation, and cognition, Ricœur's philosophical framework and cognitive

theories have different starting points, methodologies and goals. The hybrid method made it possible to understand how transfer happened and developed knowledge on how newly taught and trained HFS can become competency in QHP clinical everyday. The Ricœur's approach entails that first, in light of my final understanding of the transfer process elements, I can answer my overall research question.

The RIA has an integrated validating process. Do the findings make sense, and can they be trusted? The analysis is a helix process moving back and forth between the parts and the whole, from units of meaning (what is said/observed) to the units of significance (what is it about), comprehending what emerges 'in front of the text' (Simonÿ et al., 2018). The CEA adds another validating step of the findings, as the researcher, by viewing the situations from another perspective, should comprehend these findings as plausible and trustworthy (Steffensen et al., 2016). The RI-CEA's helix in the analytical process is illustrated by the red arrows in Figure 10, p.38. The hybrid method is experimental; further research is necessary to validate the method and understand its full potential. This challenge was addressed by involving healthcare and social science experts in facilitating reflective discussions on the hybrid method's pros, cons, and scope. There is a risk of observer bias, and a systematic variation in observations may limit the hybrid method's applicability. A challenge with the RI-CEA method is that it is time-consuming and still experimental. However, it shows advantages in shedding light on both 1st and 3rd person perspectives as the different viewpoints revealed different angles on the same situation and, thus, expanded the understanding of transfer. RI-CEA provides a foundation for future research to enhance the transfer process from training to competency. Practical implications include prioritising the organisational aspect of transferring HFS in clinical practice during course planning and extending learning beyond debriefings to transform it into competency. Collaboration with clinical practice managers is crucial for ensuring continued training and intensified implementation.

Video recordings. The use of video recordings in ethnographic studies is still in its prime. The video camera can affect people's actions and reactions in front of the camera – the Hawthorn effect – although this effect is similar to just being watched in a 'normal' ethnographic study (Asan and Montague, 2014, McCambridge et al., 2014). On the contrary, more participants said they forgot the camera after a few minutes, and it is visible in the recordings that the QHP are more relaxed and act more naturally after the first 30 min. The impact was sought to be minimised, as I wore scrubs like the QHP, used pocket-size notebooks and small GoPro cameras and participated in the care activities in varied degrees, from observer to fully engaged due to Spradley's frame for observations (Spradley, 1980). Video ethnographic data raises concerns about the confidentiality and discoverability of participants to a higher degree. I, therefore, emphasised these subjects, particularly in the information of participants before and after every data collection, and the participants made written consents, with the possibility to retract the participation. During the study period, no one withdrew their consent. Additionally, video recordings in the data collection

gained a more profound dataset, as the data did not lose its richness. It enables the capture of complex activities in their natural settings, capturing simultaneous complex interactions and creating a permanent and complete record. The recordings made revisiting the situations, behaviours, and responses possible, enabling multiple reviews – with new perspectives and understandings of what was happening – not just relying on my memories, field notes and discussions within the research group to validate findings and reduce potential biases. Finally, the SimLEARN collaboration strengthens the findings, as the researchers continuously discussed and reflected upon the interpretations and qualified the findings through that.

Design. The strength of this qualitative study is that it gets QHP's inside perspectives on the transfer of HFS and further interprets the outside perspective on their transfer process. Studies with pre-and post-tests, questionnaires and interviews open either for which knowledge QHP gained through the intervention or their perception of what they learned. Research shows that people often overestimate how they act, interact and perform (Jhangiani et al., 2014). This study data grasps what the QHP actually did before, during, and after the SBT, not what they thought they did. QHP from two different hospitals and four different departments were chosen to participate in the study because I wanted to analyse if there were differences in the degree of transfer between the smaller local hospital and the large university hospital. Due to the COVID-19 pandemic, data collection during the transfer phase was discontinued. This meant that the Transfer phase data collection happened in two wards instead of the intended four and solely within the local hospital. This weakens the finding's validity, reliability, and transferability. Recognising that the findings may vary if data from all four wards were included is crucial. Conversely, data from the clinical and SBT phases exhibit similarity, suggesting potential data compatibility from the transfer phase.

Intervention. My background as an SBT teacher meant that I could shape the training scenario according to the specific learning objectives in each ward and contain stressors and distractors to elicit participants' responses in all areas, which was an advantage. I could have managed the facilitator role in the SBT courses; however, external expert facilitators were used to increase my research focus. Two facilitators, a nurse and a doctor, were used in each scenario to gain an interdisciplinary approach to the debriefings. However, my expert knowledge in the field of SBT, thus my pre-understanding, could introduce blind spots in the observations. This bias was minimised with the SimLEARN collaboration, which added my PhD partner's outside view, joint reflections and discussion.

The SBT course was not mandatory and can give a potential risk of selection bias as it is possible that only QHP with a positive view on SBT participated. Additionally, this introduces a positive bias, as those participating likely endorsed SBT as a valuable learning method, potentially influencing the findings since participants who voluntarily engage in SBT may not represent the broader population. A spread of QHP's competence level was achieved through collaboration with the

leaders in the ward. The leaders' identification of participants potentially impacted the participants' psychological safety. Still, participants had the autonomy to decline participation. To mitigate this, participants were selected on the day from the duty personnel. Finally, it's essential to note that the data overemphasises the perspective of nurses, limiting insights into the transfer experiences of other personnel.

Pre-understanding. My pre-understanding at the beginning of the study clarified the key definitions used in this thesis and the intervention's theoretical foundation and described the ethical considerations around my role as a nurse, teacher, and researcher; my cultural and theoretical perspective was stated. Moreover, as the participants were selected to reflect an everyday team and without our influence, the PhD project's validity and reliability of this study improved. My background as a QHP and teacher could have narrowed my viewpoint, but reflections with my PhD partner compensated to a large extent. For instance, through the incipient data analysis in the Clinical phase, the SimLEARN collaboration improved the focus and the analysis. A reflection on the noise in the ward, where our experience was opposite, led to a new insight into the QHPs' use of clinical mobile phones and their culture around interruption of each other. This insight from two different scientific perspectives deepened our understanding of the field.

Analysis. The examples of findings presented in this thesis are chosen because of their patterns and representative nature. The participants 'voices' are represented in Paper II, Paper III and this thesis through direct citations, rendering of the essence of reflections and observations, and analysis examples. Moreover, co-authors participated in analysis workshops to qualify the interpretation and ensure its trustworthiness by eliminating misinterpretations or overinterpretations. This strengthens the study's reliability, although not all analyses and perspectives are represented due to the extent of the data set. Patterns were revealed by analytical coding. It would have strengthened the study if all analysis was made in NVivo, but due to IT technological issues with handling the large video files, only 1/3 of the analysis was made in NVivo (Lumivero, 2020). A complete analysis in NVivo could have revealed other essential patterns invisible to the researcher's view of the world. Additionally, as the transition from knowledge to competency takes time, more data from the Transfer phase in the university hospital or a fourth ethnographic data collection after six months might have shown further transfer of HFS.

The data material was vast – 107 hours of video. Reviewing, coding, and interpretation became a comprehensive task and introduced a risk of data overload (Arnold et al., 2023). Although much of the data was unnecessary as nothing happened (walking from A to B, waiting, etc.), the data contributed to gaining a realistic insight into the QHP's everyday clinical practice. They impacted my understanding of the complexity of the transfer process. On the one hand, the same result might have been attained with fewer data. On the other hand, the dataset gave an insightful and valuable understanding of how transfer of HFS happened.

Transferability. The knowledge derived from this study is relevant and transferable to other areas of transfer to competency. Transfer to competency is a generalised problem, not only in healthcare. However, further research is needed.

8. Conclusion

This PhD study aimed to develop new knowledge about how QHP transfers HFS taught and trained in an in situ SBT course to competency in daily clinical practice.

The study is unique because it presents the first, to my knowledge, phenomenological-hermeneutic study observing QHP before, during and after an SBT course to capture how they transfer HFS to competency in clinical practice. This study made it necessary to develop a hybrid method to analyse the data, as the perspective is both a 1st and 3rd person perspective to describe, explain and understand how the transfer from the course's learning objectives to competency occurs. The findings are also unique as they present QHP's HFS as a baseline shaping a learning intervention, participants' own experiences and ethnography of the QHP's HFS before, during and after the learning intervention and ethnographic data of the transfer processes during and after a learning intervention.

The systematic review determines that simulation-based education's positive effect is no longer disputed. SBT is trainable and can improve QHP's HFS, especially if HFS are the sole learning objective in the SBT and not an add-on to technical skills training. Further, it is concluded that research on transfer of HFS to competency in clinical practice and the retention of HFS in clinical practice is insufficient. These findings were used to form the foundation of the ethnographic study. The systematic review also shows a lack of consensus in the research and practical field regarding how HFS are monitored during SBT.

The ethnographic study suggests that the transfer of HFS from SBT to competency in clinical practice depends on daily individual, intercollegiate, and organisational support. Data show that while personal and intercollegiate transfer occurs, even if it is limited, the organisational focus of HFS needs to be improved to stimulate the transfer process. Transferring HFS from SBT to competency is considered an individual task and responsibility, like technical skills. However, the findings imply that HFS cannot be compared with technical skills. HFS are personal and team skills; thus, a team's focus on the transfer process should be applied to transfer the learning to competency. This calls for an increased organisational role, focus, and responsibility in the transfer process; re-training, re-learning, psychological safety, a team approach, motivation, support, and excellent HFS are necessary to gain sufficient patient safety in healthcare.

The findings indicate that SBT provides participants with a platform to discuss HFS and its application in daily clinical activities. It is essential to emphasise that the transfer process should be facilitated to enhance the integration of newly acquired skills into clinical competency and foster organisational learning. This can be achieved by involving clinical leaders in the process. Successful implementation of HFS from SBT into clinical competence requires a comprehensive transformation plan and sustained daily focus on applying these new skills. Moreover, adopting a broader organisational perspective on training events is crucial for transforming competency into a cultural norm rather than an individual proficiency. All human interactions in healthcare,

including cultural, social, and interpersonal skills, require efficient training to the extent of technical skills and clinical procedures, if not more, to minimise errors. HFS is not innate. The findings suggest that HFS can be developed through systematic multidisciplinary training among healthcare teams.

The roles and tasks of the transfer process are individual, intercollegiate and organisational, and all three levels are necessary for HFS to become competency in clinical practice. Turning away from silo education towards interprofessional education can be a way to gain mutual awareness and language about HFS and reflect on the QHP's behaviour and actions in clinically relevant scenarios. Additional research is imperative to deepen the understanding of the transfer to competency. This can be achieved by conducting follow-up fieldwork and focus-interviews with participants, such as evaluations after one week, one month, and three months post-SBT.

Transferring HFS to competency requires a team focus on the transfer process, organisational effort and awareness, mutual HFS language and psychological safety among QHP and leaders. Furthermore, it requires increased collaboration between simulation-based education faculty and clinical practice leaders, and last but not least, equity in the organisation between technical skills and HFS. The future calls for developing a strategy for transferring HFS after SBT, with careful planning across all three levels when implementing SBT for HFS.

9. Implications for Practice and Perspectives

This chapter finalises this PhD thesis by describing the implications for clinical practice. The findings of this study offer various perspectives on clinical practice, the transfer process of simulation-based education, and research.

Research on the transfer process of HFS from SBT to competency in the complex clinical healthcare practice is an understudied field. This thesis provides the first stepping stones and points toward future research to expand the knowledge on transferring HFS from SBT to competency in clinical practice. The findings have opened up various perspectives regarding the transfer process, including missing awareness and language of HFS, the favouritism of technical skills, QHP's constant triple awareness in teaching, learning and working, the QHP's feeling of loneliness with the responsibility of transfer new knowledge and skills and the requirement of a team focus in transferring HFS. Transferring HFS requires an intertwined focus on individual, intercollegiate, and organisational learning in the transfer phase to engender competency among QHP, comprising transfer activities on all three levels to support re-learning and transforming new skills into competency.

SBT holds the potential to enhance the HFS capabilities of qualified teams and prove effective for novices, experts, and unqualified or qualified personnel. The future focus is, though, recommended to change the primary focus of SBT for QHP from acute and critical scenarios only to urging SBT of everyday non-emergency scenarios, such as hospital admissions, rounds, or spontaneous discussions or questions in hallways. Adverse events happen not only in acute and critical situations but often in routine everyday situations. Knowing that most tasks are embedded in HFS and revolve around daily routines, involving personnel in various forms of teamwork. Drawing from the principles of Safety II, it is necessary to strengthen the ability to succeed under diverse conditions, and excellent everyday habits are more easily used in critical situations than habits trained only for acute situations. Further, QHP constantly faces new professional, environmental, or technical demands, which can create unsafe situations. High-quality HFS can, hypothetically, reduce this safety threat. Additionally, the high turnover of QHP in healthcare can impact the quality of care, a quality that continual SBT presumably can improve. If the QHP are proficient in HFS in everyday practice, they will likely succeed in acute and high-intensity situations.

Several simulation centres turn the SBT participants loose after the end of a course and presume the individual or the local organisation takes over the task of transfer and implementation. However, as the findings suggest, this does not happen. Consequently, the centre and the organisation should match their expectations instead of having unspoken beliefs. Many Simulation centres use ad hoc facilitators in the SBT. Facilitators who primarily work in the clinic. These facilitators could be part of the solution to optimise the transfer of HFS by applying them with an active role in the clinical practice to supervise and give feedback. In this way, the organisation can improve the transfer process through help from the facilitators, as the facilitators already know

and work with the HFS in the SBT. Supplementary, the organisation and the simulation centre could further increase their cooperation. SBT should be seen as more than just training HFS; instead, SBT is the beginning of improving the quality of care. The centre could have supervisors, debriefing and feedback tasks in the clinical everyday, following up after SBT. The organisation and the simulation centre should plan the transfer process; its activities, methods and focus points should be planned simultaneously as the SBT courses. Joint workshops for QHP and managers focusing on HFS could stimulate a shared understanding of HFS and begin the development of a shared language about HFS.

This thesis reveals more areas for further research, comprising the development of a generic transfer strategy with a toolbox with ideas for activities in the transfer process, study if the generic transfer strategy transfer activities can improve the extent of transfer from SBT to competency in clinical practice, and if improvements in the QHP's HFS competency decrease adverse events and consequently improve patient safety. Furthermore, research and refinement of the RI-CEA method, as integrating a 1st and 3rd person perspective in the same analytical method, could gain new perspectives in other areas where patients, relatives, QHP and organisations interact.

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11. Appendices

Appendix 1: Co-Author statement

Appendix 2: Block search - Medline

Appendix 3: Mail to departments and Collaboration contract (written mail) [Danish]

Appendix 4: Declaration of participation commitment [Danish]

Appendix 5: Information material to participating wards (PowerPoint from information meeting, Project Poster, Ward preparations, Screencast Poster, and Program for training) [Danish]

Appendix 6: Participants informed consent [Danish]

Appendix 7: Pocket-size human factor skills card [Danish]

Appendix 8: Scenario for simulation-based training (from the infectious disease ward) [Danish]

Appendix 9: Feedback to leaders with a list of trained skills, attention points and recommendations for the ward (from the emergency ward) [Danish]

Appendix 10: Approvals from the Research Ethical Committee and the Region of Southern Denmark [Danish]

Appendix 1: Co-Author statement

Declaration of co-authorship (PhD thesis)

Under Section 12 (4) of the *PhD order**, a declaration on the extent and nature of the relative contributions, signed by the collaborators and the author, must accompany the PhD thesis if the dissertation or parts of it are the result of collaboration.

Co-authors should fulfil the requirements of the Vancouver rules**

1. **General information**	
Candidate's name	Lotte Abildgren
Title of PhD thesis	From simulation-based training of human factor skills to competency in clinical practice *A qualitative investigation of how qualified in-hospital healthcare personnel transfer human factor skills from an in situ simulation-based training course to competency in the complex clinical practice.*

2. **This co-author's declaration applies to the following article/manuscript No. 1**
Abildgren, L., Lebahn-Hadidi, M., Mogensen, C. B., Toft, P., Nielsen, A. B., Frandsen, T. F., Steffensen, S. V. & Hounsgaard, L., (2022). The effectiveness of improving healthcare teams' human factor skills using simulation-based training: a systematic review, Advances in Simulation. 7, 1, 18 p., 12. The effectiveness of improving healthcare teams' human factor skills using simulation-based training: a systematic review | Advances in Simulation | Full Text (biomedcentral.com)

The extent of the candidate's contribution to the article is assessed on the following scale

A. has contributed to the work (0-33%)
B. has made a substantial contribution (34-66%)
C. did the majority of the work (67-100%)

3. **Declaration on the individual elements**	Extent (A, B, C)
1. Formulation in the concept phase of the basic scientific problem on the basis of theoretical questions which require clarification, including a summary of the general questions which it is assumed will be answered via analyses or concrete experiments/investigations.	C
2. Planning of experiments/analyses and formulation of investigative methodology in such a way that the questions asked under (1) can be expected to be answered, including choice of method and independent methodological development.	C
3. Involvement in the analysis or the concrete experiments/investigation.	C
4. Presentation, interpretation and discussion of the results obtained in the form of an article or manuscript.	C

4. Co-authors' signatures			
Date	Name	Title	Signature
09.10.23	Lise Hounsgaard	Professor	
15.10.23	Sune Vork Steffensen	Professor	
05.11.23	Malte Lebahn-Hadidi	PhD	
10.10.23	Palle Toft	Professor	
02.11.23	Christian Backer Mogensen	Professor	
04.11.23	Anders Bo Nielsen	PhD	
04.11.23	Tove Faber Frandsen	Professor	

5. Candidate's signature

2. **This co-author's declaration applies to the following article/manuscript No. 2**
Abildgren, L., Lebahn-Hadidi, M., Mogensen, C. B., Toft, P., Steffensen, S. V. & Hounsgaard, L., Transfer human factor skills from simulation-based training to competency in clinical practice – a demonstration of a hybrid method for assessing transfer of learning.

The extent of the candidate's contribution to the article is assessed on the following scale

A. has contributed to the work (0-33%)
B. has made a substantial contribution (34-66%)
C. did the majority of the work (67-100%)

3. **Declaration on the individual elements**	Extent (A, B, C)
1. Formulation in the concept phase of the basic scientific problem on the basis of theoretical questions which require clarification, including a summary of the general questions which it is assumed will be answered via analyses or concrete experiments/investigations.	C
2. Planning of experiments/analyses and formulation of investigative methodology in such a way that the questions asked under (1) can be expected to be answered, including choice of method and independent methodological development.	C
3. Involvement in the analysis or the concrete experiments/investigation.	C
4. Presentation, interpretation and discussion of the results obtained in the form of an article or manuscript.	C

4. **Co-authors' signatures**			
Date	Name	Title	Signature
09.10.23	Lise Hounsgaard	Professor	
15.10.23	Sune Vork Steffensen	Professor	
05.11.23	Malte Lebahn-Hadidi	PhD	
10.10.23	Palle Toft	Professor	
02.11.23	Christian Backer Mogensen	Professor	

5. **Candidate's signature**

2. **This co-author's declaration applies to the following article/manuscript No. 3**
Abildgren, L., Lebahn-Hadidi, M., Mogensen, C. B., Toft, P., Steffensen, S. V. & Hounsgaard, L., From simulation-based training to competency in clinical practice – Findings from a qualitative investigation of transferring human factor skills.

The extent of the candidate's contribution to the article is assessed on the following scale

A. has contributed to the work (0-33%)
B. has made a substantial contribution (34-66%)
C. did the majority of the work (67-100%)

3. **Declaration on the individual elements**	Extent (A, B, C)
1. Formulation in the concept phase of the basic scientific problem on the basis of theoretical questions which require clarification, including a summary of the general questions which it is assumed will be answered via analyses or concrete experiments/investigations.	C
2. Planning of experiments/analyses and formulation of investigative methodology in such a way that the questions asked under (1) can be expected to be answered, including choice of method and independent methodological development.	C
3. Involvement in the analysis or the concrete experiments/investigation.	C
4. Presentation, interpretation and discussion of the results obtained in the form of an article or manuscript.	C

4. **Co-authors' signatures**			
Date	Name	Title	Signature
09.10.23	Lise Hounsgaard	Professor	
15.10.23	Sune Vork Steffensen	Professor	Sune Vork Steffensen
05.11.23	Malte Lebahn-Hadidi	PhD	
10.10.23	Palle Toft	Professor	
02.11.23	Christian Backer Mogensen	Professor	Christian Backer Mogensen

5. **Candidate's signature**

2. **This co-author's declaration applies to the following article/manuscript No. A**
Lebahn-Hadidi, M., Abildgren, L., Hounsgaard, L. & Steffensen, S. V., (2023). Integrating cognitive ethnography and phenomenology: rethinking the study of patient safety in healthcare organizations, Phenomenology and the Cognitive Sciences. 22, 1, p. 193–215. Integrating cognitive ethnography and phenomenology: rethinking the study of patient safety in healthcare organisations | SpringerLink

The extent of the candidate's contribution to the article is assessed on the following scale

A. has contributed to the work (0-33%)
B. has made a substantial contribution (34-66%)
C. did the majority of the work (67-100%)

3. **Declaration on the individual elements**	Extent (A, B, C)
1. Formulation in the concept phase of the basic scientific problem on the basis of theoretical questions which require clarification, including a summary of the general questions which it is assumed will be answered via analyses or concrete experiments/investigations.	A
2. Planning of experiments/analyses and formulation of investigative methodology in such a way that the questions asked under (1) can be expected to be answered, including choice of method and independent methodological development.	A
3. Involvement in the analysis or the concrete experiments/investigation.	A
4. Presentation, interpretation and discussion of the results obtained in the form of an article or manuscript.	A

4. **Co-authors' signatures**			
Date	Name	Title	Signature
09.10.23	Lise Hounsgaard	Professor	
15.10.23	Sune Vork Steffensen	Professor	
10.10.23	Malte Lebahn-Hadidi	PhD	

5. **Candidate's signature**

2. **This co-author's declaration applies to the following article/manuscript No. B**
Lebahn-Hadidi, M., Abildgren, L., Hounsgaard, L., Mogensen, C. B. & Steffensen, S. V., Beyond *No Interruptions Zones* in the medicine room: Patient safety through human factors training. (Draft)

The extent of the candidate's contribution to the article is assessed on the following scale

A. has contributed to the work (0-33%)
B. has made a substantial contribution (34-66%)
C. did the majority of the work (67-100%)

3. **Declaration on the individual elements**	Extent (A, B, C)
1. Formulation in the concept phase of the basic scientific problem on the basis of theoretical questions which require clarification, including a summary of the general questions which it is assumed will be answered via analyses or concrete experiments/investigations.	B
2. Planning of experiments/analyses and formulation of investigative methodology in such a way that the questions asked under (1) can be expected to be answered, including choice of method and independent methodological development.	B
3. Involvement in the analysis or the concrete experiments/investigation.	A
4. Presentation, interpretation and discussion of the results obtained in the form of an article or manuscript.	A

4. **Co-authors' signatures**			
Date	Name	Title	Signature
09.10.23	Lise Hounsgaard	Professor	
15.10.23	Sune Vork Steffensen	Professor	
05.11.23	Malte Lebahn-Hadidi	PhD	
10.10.23	Palle Toft	Professor	
02.11.23	Christian Backer Mogensen	Professor	

5. **Candidate's signature**

*The Danish *Ministerial Order on the PhD Programme at the Universities (PhD order)*, no. 18 of 14 January 2008

**Vancouver rules: "All persons named as authors must satisfy the authorship requirement. The order of names must be a joint decision taken by all the authors. The individual author must have participated in the work to a sufficient extent to be able to accept public liability for the content of the scientific work. Authorship can only be based on substantial contribution with regard to: 1) conception and design or analysis and interpretation of data, 2) drafting the article or revising it critically for important intellectual content, and 3) final approval of the version to be published. *Involvement based only on obtaining funding for the work or collecting data does not qualify for authorship. Neither does general supervision of the research group in itself qualify as authorship.* If the authorship is collective, key persons who are responsible for the article must be identified. The editors of the scientific periodical may ask authors to account for their part in the authorship."

Appendix 2: Block search - Medline

	MEDLINE 28.09.2021	
	Searches	**Results**
1	exp simulation training/	8781
2	(simulat* adj5 (educat* or cours* or workshop* or boot-camp* or bootcamp* or learn* or experienc* or curricul* or framework* or teach* or guid* or coach* or supervis* or seminar* or lectur* or round* or tutor* or mentor* or program* or training* or event*)).mp.	30903
3	(high adj3 fidelity adj5 (educat* or cours* or workshop* or boot-camp* or bootcamp* or learn* or experienc* or curricul* or framework* or teach* or guid* or coach* or supervis* or seminar* or lectur* or round* or tutor* or mentor* or program* or training* or event*)).mp.	1248
4	(hi-fi* adj5 (educat* or cours* or workshop* or boot-camp* or bootcamp* or learn* or experienc* or curricul* or framework* or teach* or guid* or coach* or supervis* or seminar* or lectur* or round* or tutor* or mentor* or program* or training* or event*)).mp.	8
5	(in adj3 situ adj5 (educat* or cours* or workshop* or boot-camp* or bootcamp* or learn* or experienc* or curricul* or framework* or teach* or guid* or coach* or supervis* or seminar* or lectur* or round* or tutor* or mentor* or program* or training* or event*)).mp.	2453
6	(insitu adj5 (educat* or cours* or workshop* or boot-camp* or bootcamp* or learn* or experienc* or curricul* or framework* or teach* or guid* or coach* or supervis* or seminar* or lectur* or round* or tutor* or mentor* or program* or training* or event*)).mp.	4
7	(full adj3 scale* adj5 (educat* or cours* or workshop* or boot-camp* or bootcamp* or learn* or experienc* or curricul* or framework* or teach* or guid* or coach* or supervis* or seminar* or lectur* or round* or tutor* or mentor* or program* or training* or event*)).mp.	351
8	1 or 2 or 3 or 4 or 5 or 6 or 7	36633
9	NTS.mp.	6861
10	(non adj5 technical adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	837
11	(non-technical adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	804
12	(nontechnical adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	423
13	(soft adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	5175
14	exp leadership/	40765
15	(leadership* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	12665
16	(situation adj3 awareness* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	192
17	exp fatigue/	30055
18	(fatigue* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	8373

19	exp cooperative behavior/	43185
20	(cooperat* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	49486
21	exp intersectoral collaboration/	1876
22	(collabor* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	12382
23	exp decision making/	199983
24	(decision adj3 making* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	26968
25	exp patient care team/	67967
26	(teamwork* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	3014
27	(safe* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	50060
28	(error* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	8495
29	exp cultural competency/	5458
30	(cultural adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	21893
31	exp social skills/	1719
32	(social adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	161133
33	(followership* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	28
34	(CRM* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	463
35	(crisis adj3 resource adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	229
36	exp interprofessional relations/	68975
37	(interprof* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	52461
38	(inter-prof* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	402
39	(interhuman adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	19
40	(inter-human* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	11
41	(interact* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	67235
42	(inter-act* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	14
43	exp interdisciplinary communication/	16995

44	(interperson* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	83626
45	(inter-person* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	179
46	(interdiscipli* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	20782
47	(inter-disciplinary* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	76
48	(multidiscipli* adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	11072
49	(multi-discipli** adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	717
50	exp attitude of health personnel/	157225
51	(doctor adj3 nurse adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	242
52	exp physician-nurse relation/	2355
53	(physician adj3 nurse adj5 (barrier* or behav* or cognit* or competenc* or communicat* or expertise* or knowlegd* or manage* or relation* or skill* or understand*)).mp.	2910
54	9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53	916638
55	8 and 54	5357

Odense, 2. oktober 2018

Appendix 3: Mail to departments and Collaboration contract

Kære Afdelingsledelser

Anæstesiologisk-Intensiv Afdeling V, OUH
Infektionsmedicinsk Afdeling Q, OUH
Intensiv Afdeling, SHS
Akutcenter, Aabenraa, SHS

Vedr. ph.d.projektet 'SimLEARN: Reduktion af utilsigtede hændelser gennem læringstransfer af non-technical skills'

Vi har tidligere modtaget jeres mundtlige tilsagn til at udføre dataindsamling til projektet, i jeres afdeling. Projektet officielt påbegyndt 1. september 2018 hvorfor vi nu har behov for et **skriftligt tilsagn** som skal vedlægges ansøgningen til Videnskabsetisk komité.

Vi skal undersøge om træning af personalet i egen afdeling kan være med til at forbedre pleje, behandling og samarbejde. Vi ønsker derfor at samle data om sundhedspersonalets læring gennem simulationstræning i jeres afdeling.

Formålet med studiet er:

- at udvikle viden om hvordan personalet anvender ny viden og kompetencer i deres kliniske arbejde, herunder hvordan læring overføres fra simulation til handlekompetence gennem praksistræning i egen afdeling.
- at udvikle viden om hvordan patientsikkerheden optimeres på hospitalerne gennem bedre ikke-tekniske færdigheder. Fokus er på personalet som helhed og deres interaktion, kommunikation og teamsamarbejde. Derfor er fokus ikke på det enkelte personalemedlem.

Jeres tilsagn giver os tilladelse til at:
1) Observere og optage personalets samarbejde, handlinger og kommunikation samt foretage uformelle samtaler med personale, patient og pårørende, før, under og efter simulationstræningen.
2) Udføre in situ simulationstræningskursus i afdelingen med efterfølgende debriefing.

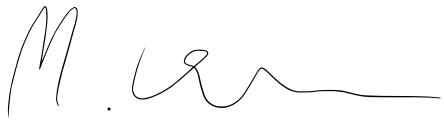
Sådan foregår det helt praktisk:
Observationerne vil foregå ved at vi er til stede på stuerne sammen med personalet, hvor vi vil observere personalets interne samspil med hinanden og patient/pårørende. Vi vil skrive noter og videodokumentere, der skal hjælpe os med at huske observationer. Vi deltager således ikke aktivt i hverken pleje eller behandling. Videodata vil kun blive anvendt i forskningssammenhæng og kun i forskningsformidling efter anonymisering og aftale med de berørte informanter.

Vi har samme tavshedspligt som personalet. Vores datamateriale og kendskab til projektets deltagere og øvrige patienter i afdelingen vil blive behandlet anonymt og fortroligt, og i overensstemmelse med EU's Databeskyttelsesforordningen á 2018.

Vi vil gerne præsentere projektet, dataindsamlingen og anvendelse af data på et personalemøde eller lignende inden opstart, således personalet får indsigt i projektet og gives mulighed for at stille spørgsmål. Artikler og andet offentliggjort materiale omkring projektet fremsendes til afdelingen, ligesom I inviteres til de afsluttende ph.d.-forsvar.

Odense, 2. oktober 2018

Med venlig hilsen
Projektansvarlige
Malte Lebahn & Lotte Abildgren



Malte Lebahn
Cand.mag., ph.d. studerende
lebahn@sdu.dk
☎ 2671 7420

Lotte Abildgren
Sygeplejerske, cand.cur., ph.d. studerende
lotte.abildgren@rsyd.dk
☎ 2498 8036

Vejledere på projektet:

- **Lise Hounsgaard,** professor, OPEN, Klinisk Institut, Det Sundhedsvidenskabelige Fakultet, SDU & Center for Sundhedsforskning, University College Lillebaelt

- **Sune Vork Steffensen,** professor, centerleder, ved Centre for Human Interactivity, Institut for kommunikation, SDU.

- **Christian Backer Mogensen,** professor, overlæge, Akutcenter, Aabenraa

- **Palle Toft,** professor og læge, Anæstesiologisk-Intensiv Afdeling V, Odense Universitetshospital.

Appendix 4: Declaration of participation commitment

Odense d. 8.10.18

Bekræftelse

Afdelingsledelsen, Infektionsmedicinsk Afdeling Q, OUH bekræfter hermed deltagelse vedr. ph.d projekt "SimLEARN: Reduktion af utilsigtede hændelser gennem læringstransfer af non-technical skills"

Der gives hermed tilladelse til at observere og optage personalets samarbejde, handlinger og kommunikation efter nærmere aftale og efter gældende retningslinjer.

Svend Stenvang

Ledende overlæge

OUH Odense Universitetshospital

Bent Schwartz

Oversygeplejerske

Appendix 5: Information material to participating wards

The information material for the participating ward comprises

- PowerPoint from information meeting
- Project poster for note boards in the wards
- Ward preparations lists
- Screencast poster for note boards in the wards and emails for the healthcare personnel
- Program for training

SimLEARN

Reduktion af utilsigtede hændelser gennem transfer af non technical skills

- Præsentation
- Problemstilling
- Formål
- Hvordan?
- Resultater
- Spørgsmål

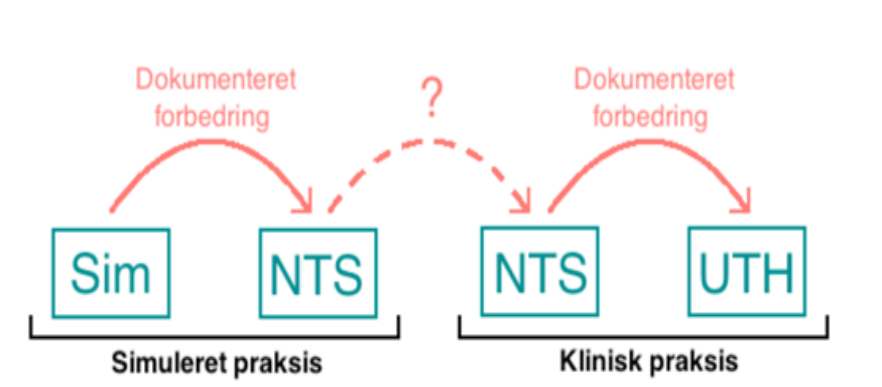
Hvem er vi?

- Malte Lebahn, HUMANIORA
  cand.mag. – kommunikation
- Lotte Abildgren, OPEN, sundhedsvidenskab
  cand.cur. – intensiv sygeplejerske

Problemstillingen

1. Utilsigtede hændelser er et internationalt, nationalt og lokalt problem
2. Utilsigtede hændelser kan undgås (reduceres markant) gennem uddannelse af sundhedspersonale
3. Transfer af læring kan undersøges vha. in situ simulation træning

The missing link



Figur 1: *Forskningens missing link mellem Non-Technical Skills i simuleret og klinisk praksis*

Formål & hypotese

- Formålet er, at undersøge transfer af læring gennem simulationstræning
- Hypotesen er, at reduktion af utilsigtede hændelser kan ske ved træning af sundhedspersonalets ikke tekniske færdigheder

Hvordan

	Ph.d. Health Science Teamwork	Ph.d. Social Science Medicine handling
Before (simulation)	Activity: Literature overview, patient interviews, field introduction, assessment of baseline Empiric data: Ethnographic data, interviews, ANTS score Article: Review - Teamwork	Activity: Literature overview, patient interviews, field introduction, assessment of baseline Empiric data: Ethnographic data, interviews Article: Review – Medicine handling
During (simulation)	Activity: In situ simulation training Empiric data: Ethnographic data, video recordings Article: Results - In-situ Training (Teamwork)	Activity: In situ simulation Empiric data: Ethnographic data, video recordings Article: Results - In-situ Training (Medicine handling)
After (simulation)	Activity: Field observations, assessment of transfer , patient interviews Empiric data: Ethnographic data, ANTS score Article: Results – Transfer (teamwork)	Activity: Field observations, knowledge workshop, patient interviews Empiri: Ethnographic data, essays / tales Article: Results – Transfer (medicine handling)
	Activity: Development of generic concept for assessment of transfer, conclusion based on results, preparation of thesis Article: Joint conclusion - Methodology for ensuring of learning transfer	

Figur 1: *Flowdiagram over forskningsprojektets faser.*

Information

Informeret samtykke

(S1)
Informeret samtykke til deltagelse i et sundhedsvidenskabeligt forskningsprojekt.

Forskningsprojektets titel: SimLEARN: Reduktion af utilsigtede hændelser gennem læringstransfer af non-technical skills

Erklæring fra forsøgspersonen:
Jeg har fået skriftlig og mundtlig information og jeg ved nok om formål, metode, fordele og ulemper til at sige ja til at deltage.
Jeg ved, at det er frivilligt at deltage, og at jeg altid kan trække mit samtykke tilbage uden at miste mine nuværende eller fremtidige rettigheder til behandling.
Jeg giver samtykke til, at deltage i forskningsprojektet, og har fået en kopi af dette samtykkeark samt en kopi af den skriftlige information om projektet til eget brug.

Forsøgspersonens navn: _____

Dato: _____ Underskrift: _____

Ønsker du at blive informeret om forskningsprojektets resultat samt eventuelle konsekvenser for dig?:

Ja ____ (sæt x) Nej ____ (sæt x)

Erklæring fra den, der afgiver information:
Jeg erklærer, at forsøgspersonen har modtaget mundtlig og skriftlig information om forsøget.

Efter min overbevisning er der givet tilstrækkelig information til, at der kan træffes beslutning om deltagelse i forsøget.
Navnet på den, der har afgivet information: *Lotte Abildgren*

Dato: 25. oktober 2018 Underskrift: _____

Projektidentifikation: (Fx komiteens Projekt-ID, EudraCT nr., versions nr./dato eller lign.)

Forventet outcome

- Betydning for klinisk praksis
- Betydning for klinisk uddannelse og simulationstræning
- Potentiale i forskningsfeltet

Spørgsmål?

Thank you!

- Malte Lebahn, malte.lebahn@gmail.com
  +45 26 71 74 20
- Lotte Abildgren, lotte.abildgren@rsyd.dk
  +45 24 98 80 36

Extra: Method - Field

	Intensiv afd.	Hæmatol. afd.
OUH	V_O (850, 167)	X_O (130, 146)
SHS	V_S (240, 85)	X_S (5, 7)

Signaturer (2015-tal):
~Antal medarbejdere
Antal UTH'er

Figur 2: *Forskningsprojektets fire sites [11]*

Appendix 6: Participants informed consent

(S1)

Informeret samtykke til deltagelse i et sundhedsvidenskabeligt forskningsprojekt.

Forskningsprojektets titel: SimLEARN: Reduktion af utilsigtede hændelser gennem læringstransfer af non-technical skills

Erklæring fra forsøgspersonen:

Jeg har fået skriftlig og mundtlig information og jeg ved nok om formål, metode, fordele og ulemper til at sige ja til at deltage.

Jeg ved, at det er frivilligt at deltage, og at jeg altid kan trække mit samtykke tilbage uden at miste mine nuværende eller fremtidige rettigheder til behandling.

Jeg giver samtykke til, at deltage i forskningsprojektet, og har fået en kopi af dette samtykkeark samt en kopi af den skriftlige information om projektet til eget brug.

Forsøgspersonens navn: [redacted]

Dato: 20.09.19 Underskrift: _____

Ønsker du at blive informeret om forskningsprojektets resultat samt eventuelle konsekvenser for dig?:

Ja X (sæt x) Nej _____ (sæt x)

Erklæring fra den, der afgiver information:

Jeg erklærer, at forsøgspersonen har modtaget mundtlig og skriftlig information om forsøget.

Efter min overbevisning er der givet tilstrækkelig information til, at der kan træffes beslutning om deltagelse i forsøget.

Navnet på den eller dem, der har afgivet information: *Lotte Abildgren & Malte Lebahn*

Dato: 10. september 2019 Underskrift: _____

Dato: 10. september 2019 Underskrift: _____

Projektidentifikation: (Videnskabsetisk Komite, Sagsnummer 20182000-140)

Projektansvarlige
Malte Lebahn, ph.d. studerende lebahn@sdu.dk ☎2671 7420
Lotte Abildgren, ph.d. studerende lotte.abildgren@rsyd.dk ☎2498 8036

Appendix 7: Pocket-size human factor skills card

Lederskab
Påtager sig lederrollen
Uddelegerer / koordinere opgaver
Udviser autoritet og gennemslagskraft
Skabe og bevare overblikket
Prioritering
Følgeskab
Teamet spiller lederen god
Udfører opgaver
Opbakning og støtte
Anvender ISBAR / closed Loop
Kommer med forslag
Teamwork
Udveksle information
Kommunikere og opdater sammen
Vurdere roller og kompetencer
Koordinere aktiviteter
Støtte teamet medlemmer
Arbejder sammen for at nå bedst mulig mål
Situationsbevidsthed
Indsamle information
Erkende og forstå sammenhænge
Forudse og tænke fremad
Anvendelse af sanser og erfaringer
Krydstjekke oplysninger
Beslutningstagen
Identificere handlingsmuligheder
Vurdere og balancere muligheder / risici
Revurdere beslutninger
Anvende beslutningsstøtte
Inddrage teamet
Observation, analyse og intervention

Appendix 8: Scenario for simulation-based training

Til Instruktør og operatør

Jette Nielsen, 82 år

Forhistorie:
Jette har været indlagt på medicinsk afdeling under diagnosen apoplexia cerebri og udskrevet for 6 dage siden. Hun har ligget på Q de sidste 2 dage. Genindlægges via FAM fra plejehjemmets aflastningsstue pga. tiltaget forvirring og nedtrykthed og feber. Opstartet i pip tazo 4g/0,5 iv x 4. Fokus ukendt. Jette er lidt af et livstykke, og har underholder med historier fra gamle dage. I dag har Jette været sengeliggende og har ikke ønsket at komme op og sidde eller træne. Er nedtrykt og opgivende.

Aktuelt:
Jette ligger på to-sengsstue og har klaret sig med hjælp fra SSA til personlig hygiejne og blendet FK

Medicin:
Det der er tilgængeligt i afdelingen

Læringsmål		Objektivt				Mulige handlinger
		Ved scenariestart	**Event start**		**Event slut**	
Ikke tekniske HUMAN FACTORS • Udøv lederskab og følgeskab • Teamwork • Beslutningstagen • Situationsbevidsthed • Mobiliser tilgængelige ressourcer • Kommuniker effektivt	**A**	• Frie luftveje • Taler	• Frie luftveje • Taler	• Frie luftveje • Taler	• Frie luftveje • Taler	• ABCDE • ISBAR /closed loop • Timeout/opsummering • Monitorering (BT, SAT, Puls, EKG, RF, Temp) • Tilkalde hjælp • Ilt behandling • A-punktur • Uddybe anamnese • Trendelenburgs leje • Anlægge store i.v. adgange • Gennemdyrkning, inkl. venyler • Væske behandling • Blodprøver • Opstarte antibiotika behandling jf. anbefaling. • Rtg. af thorax
	B	• RF: 25 • SAT: 90 • St.p.: krep. Basalt ve. • Takypnø	• RF: 25 • SAT: 90 • St.p.: krep. Basalt ve. • Takypnø	• RF: 35 • SAT: 85 • St.p.: krep. Basalt ve. • Takypnø	• RF: 25 • SAT: 93 • St.p.: krep. Basalt ve. • Takypnø	
	C	• P: 110 • BT: 110/55 • EKG: Sinustaky.	• P: 110 • BT: 110/55 • EKG: Sinustaky.	• P: 135 • BT: 80/35 • EKG: Sinus takykardi	• P: 110 • BT: 100/60 • EKG: Sinus taky.	
	D	• GCS: 15 • BS: 8,2 • Opgivende, trist • Egale pupiller	• GCS: 15 • BS: 8,2 • Opgivende, trist • Egale pupiller	• GCS: 13 • BS: 8,2 • Dalende bevidsthed • Urin konc + bact.	• GCS: 15 • BS: 8,2 • Afkræftet, relevant	
	E	• Tp.: 39,1 • Varm / blussende	• Tp.: 39,1 • Varm / blussende	• Tp.: 39,1 • Klamtsvendende	• Tp.: 39,1 • Varm	
		Paraklinisk				
			• A gas x 2 • Journal • CT-C	• EKG		

Rollelister samt instruktionsvejledning

Rolle	Sygeplejerske 1	Sygeplejerske 2	Studerende / Nyansat	Læge 1	Læge 2	Patient Stemme
Instruktion	Du kommer tilfældigt forbi stuen og finder Jette halvafklædt og rodende i sengen	Du er ved at give IV AB til en patient. Du ankommer efter 2-3 minutter	Du er studerende / nyansat i afdelingen og følges med sygeplejerske 1. Du stiller spørgsmål og hjælper til hvor dine kompetencer rækker.	Du er ved at lave modtagenotat på anden patient og kan komme på stuen efter 3 minutter Patienten er meldt som infektion med ukendt fokus	Du er ved at diktere på anden patient og kan komme på stuen efter 3 minutter	Jette skal ligge med venstre arm ud over sengekanten, halvt afklædt. **Start:** ”Jeg syntes, at jeg har rigtig skidt - jeg har sådan en kvalme - jeg føler mig så utilpas - jeg har ikke haft det sådan før -hjælp mig. Åh jeg gider ikke leve mere. Min mand gider nok ikke passe mig hvis jeg ikke kan klare mig selv. Åh nu syntes jeg at jeg skal kaste op…” **Efter 5-10 min:** Mumler, svarer usammenhængende. **Ved korrekt beh.:** ”Hvad foregår der. Hvor er jeg?, Jeg føler mig så forvirret, Jeg er så træt, er det normalt? Kommer min mand?” Jettes mand Åge har svært ved at gå uden støtte og benytter rollator.
	Forløb Jette ligger halvt afklædt og rodende i sengen → ikke helt nemt at samarbejde om værdier → forkvalmet og opkast lyde → cirkulatorisk ustabil, respiratorisk påvirket, dalende bevidsthedsniveau → behandling af sepsis, væske, antibiotika					

Udstyrslister og arbejdsfordeling

Ved scenariestart	Undervejs i scenariet
• Nursing Anne (Bolette) i ført joggingtøj • Identifikationsarmbånd • Billede af Jette 82 år • Monitoreringsudstyr (BT, SAT, TP, Pupillygte) • PVK • Iltbrille • Patienttøj	• KAD - straks 200 ml koncentreret urin. • Hudsonmaske • A-gas • EKG • Rtg. thorax

Hvem gør hvad?			
Tekniker	**Instruktør 1**	**Instruktør 2**	**Observatør**
• Forbereder simulator • Ilt brille • Venflon • Tøjet sidder sjusket • Arm hænger ud over sengen	• Sikre paraklinik og journal • Introducerer til stue/simulator • Er på stuen • Vejleder kursisterne ved behov • Sikrer, at der ikke sker skade på udstyr	• Stressorer kan være beskeder ind ad døren eller forespørgsler fra læge eller andet personale	Når det tværfaglige samarbejde lykkes/er godt

Journal

Jette Nielsen
050637-9784

Alder: 82 år Vægt:95 kg Højde: 163 cm Udsende: Akut medtaget

Tidligere:
Juni 1991: Opereret for brok

Medicin:
Medicin mod eksem, naturprodukt, husker ikke navn

Allergi:
Ingen kendte

Tobak:
Ved festlige lejligheder. Rygeophør for 20 år siden.

Spiritus:
8 genstande om ugen. Har tidligere haft et stort alkoholforbrug

Socialt:
Bor sammen med mand. 4 børn sammen, alle voksne. Tidligere kogekone

Tidligere notater
82 årig kvinde indlagt under diagnosen Hæmorhagia cerebri obs pro.

Allergier: Ingen kendte. Tåler penicillin

Tidligere:
1991: Opereret for venstresidig lyskebrok på Hvidovre Hospital

Anamnese:
Anamnese optaget med informationer fra ægtefælle.
Patienten indlagt med 112. Patienten er fundet bevidstløs af ægtefælle på toilettet.
Da ambulancen ankommerer patienten vågnet lidt op, men er snøvlende og kan ikke kooperere.
Der er ikke observeret kramper eller lignende. Ingen afgang af fæces eller urin i forbindelse med episoden. Aldrig haft sådanne symptomer tidligere.

Øvrige organsystemer:
CNS: Ingen epilepsi eller tendes til besvimmelse. Intet besvær med at huske. Ingen syns- eller hørehandikap.
CP: Ingen hjertesmerte eller tendens til lufthunger. Fysisk inaktiv.
GI: Ingen klager ud over tendens til obstipation.
UG: Hyppige vandladninger og nykturi.
Bevægeapparat: Smerter gennem mange år i begge knæ og ryg, tilskrives slid.

Medicin: Naturmedicin mod eksem. Husker ikke præparatets navn.
Tobak: Ved festlige lejligheder. Ophørt rygning for 20 år siden
Alkohol: Ca. 8 genstande om ugen. Tidligere betydeligt forbrug.

Socialt: Bor med ægtefælle, som er dårligt gående (rollator). Klarer de fleste opgaver i hjemmet. 4 voksne børn. Tidligere arbejdet som kogekone.

Objektivt:
BT 183/100 P 66 ET over middel Kronisk medtaget udseende

Neurologisk: Mobilitetsudfald på hele venstre side. Talen snøvlende, men indhold skønnes relevant.
Ikke muligt at få patienten til at kooperere sufficient
Stet P et C: Lille mislyd over hele cor ellers intet abnormt. Let krepitation på hø. Lungeflade basalt.
Abd.: Blød og uømt uden palp. Udfyldninger. Nat. Tarmlyde.
Rect. Ekpl.: Ej udført
Ekstr.: Ingen tegn på fraktur

/Haemorhagia cerebri op/
/Apoplexia cerebro op/
/TCI lille op/
Commotio cerebri op/

Udskrives til plejecenter til genoptræning

FAM

Genindlægges til obs. for ny apoplexia.
Gennemdyrkes, standard blodprøver
Tp. 38,2
Finder forhøjet infektionstal, opstartet i Pip Tazo 4g/0,5g iv x 4.
Overflyttes til Q mhp. Fund af fokus og iv antibiotika behandling.

Q
Rtg. Thorax ia
Ingen svar på dyrkninger endnu, afventer
Blank urinstix

RADIOMETER ABL800 FLEX
Ankomst på FAM

ABL835 ITA		13:47	25-10-2023
PATIENT-RAPPORT	Sprøjte-S 195µL	nr	123456

Identifikationer	
Patient id	131076-7893
Prøveglas nr.	131076-7893
Prøvetype	Arteriel
Patientens efternavn	Nielsen
Patientens fornavn	Jette
Patient note	
T	37,0°C

Blodgas-Værdier			**ref.værdier**
pH	7,422		
pCO_2	5,1	kPa	
pO_2	11,1	kPa	
ABE_c	-2,0	mmo/L	
sO_2	0,967		
$_cHCO_3^-(P.st)_c$	24,0	mmo/L	
$_cHCO3^-(P)c$	22,1	mmo/L	
Oximetri-Værdier			
$_ctHb$	8,9	mmo/l	
Hct_c	0,245		
FCOHb	0,014		
FMetHb	0,006		
Elektrolyt-Værdier			
cNa^+	145	mmo/l	136-146
cK^+	4,4	mmo/l	3,3-4,7
$_cCa^{2+}$	1,13	mmo/l	
$_cCa^{2+}(7,4)_c$	1,14	mmo/l	1,19-1,29
$_cCl^-$	103	mmo/l	
Metabolit-Værdier			
cGlu	8,2	mmo/l	
cLac	1,2	mmo/l	
ctBil	10	µmo/l	
Temp.-Korrigerde Værdier			
pH(T)	7,422		
$pCO_2(T)$	5,1	kPa	
$pO_2(T)$	11,1	kPa	

Noter

Beregnede værdi(er)

Udskrevet	13:49	25-10-2023

RADIOMETER ABL800 FLEX
Forværring

ABL835 ITA		14:47	25-10-2023
PATIENT-RAPPORT	Sprøjte-S 195µL	nr	123456

Identifikationer	
Patient id	131076-7893
Prøveglas nr.	131076-7893
Prøvetype	Arteriel
Patientens efternavn	Nielsen
Patientens fornavn	Jette
Patient note	
T	37,0°C

Blodgas-Værdier			**ref.værdier**
pH	7,299		
pCO_2	3,5	kPa	
pO_2	9,5	kPa	
ABE_c	-9,0	mmo/L	
sO_2	0,907		
$_cHCO_3^-(P.st)_c$	16,0	mmo/L	
$_cHCO3^-(P)c$	15,1	mmo/L	
Oximetri-Værdier			
$_ctHb$	8,3	mmo/l	
Hct_c	0,245		
FCOHb	0,014		
FMetHb	0,006		
Elektrolyt-Værdier			
cNa^+	143	mmo/l	136-146
cK^+	4,3	mmo/l	3,3-4,7
$_cCa^{2+}$	1,13	mmo/l	
$_cCa^{2+}(7,4)_c$	1,14	mmo/l	1,19-1,29
$_cCl^-$	103	mmo/l	
Metabolit-Værdier			
cGlu	7,9	mmo/l	
cLac	5,0	mmo/l	
ctBil	10	µmo/l	
Temp.-Korrigerde Værdier			
pH(T)	7,299		
$pCO_2(T)$	3,5	kPa	
$pO_2(T)$	9,5	kPa	

Noter

Beregnede værdi(er)

Udskrevet	14:49	25-10-2023

Fælles svar - Undervisningsmateriale

Jette Nielsen

Tlf: 6541
1926/1924

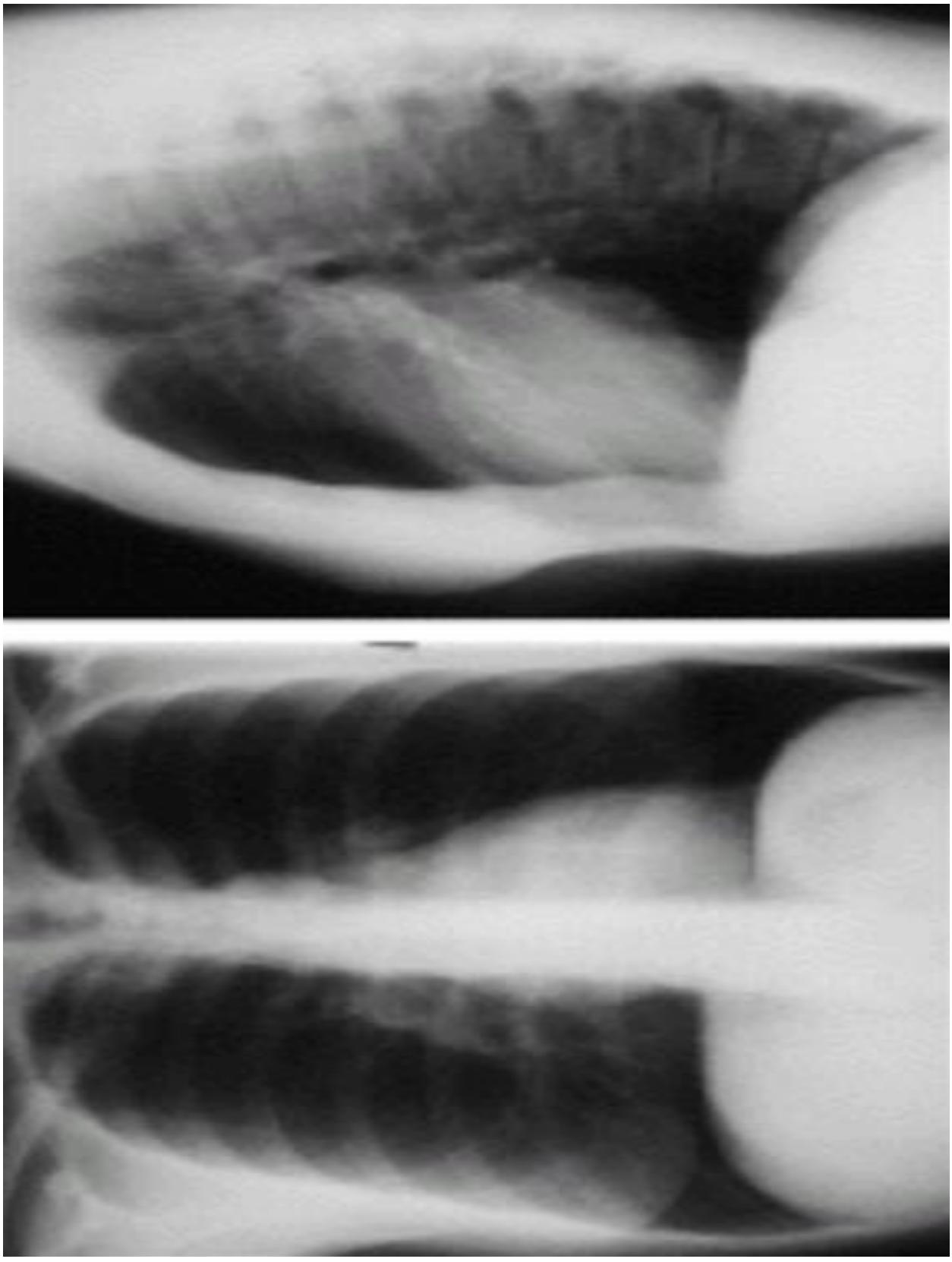
FAM

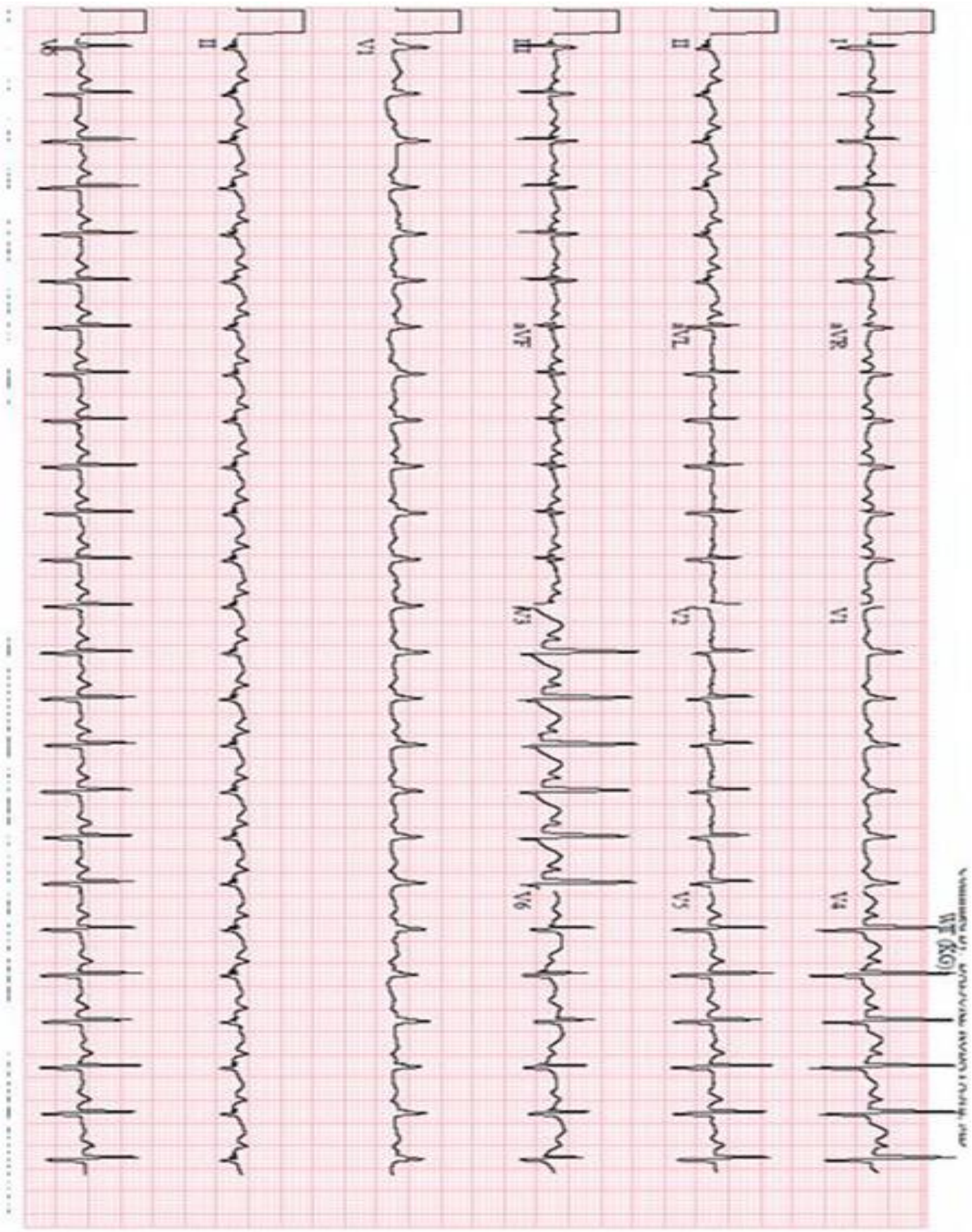
ENKELTSVAR

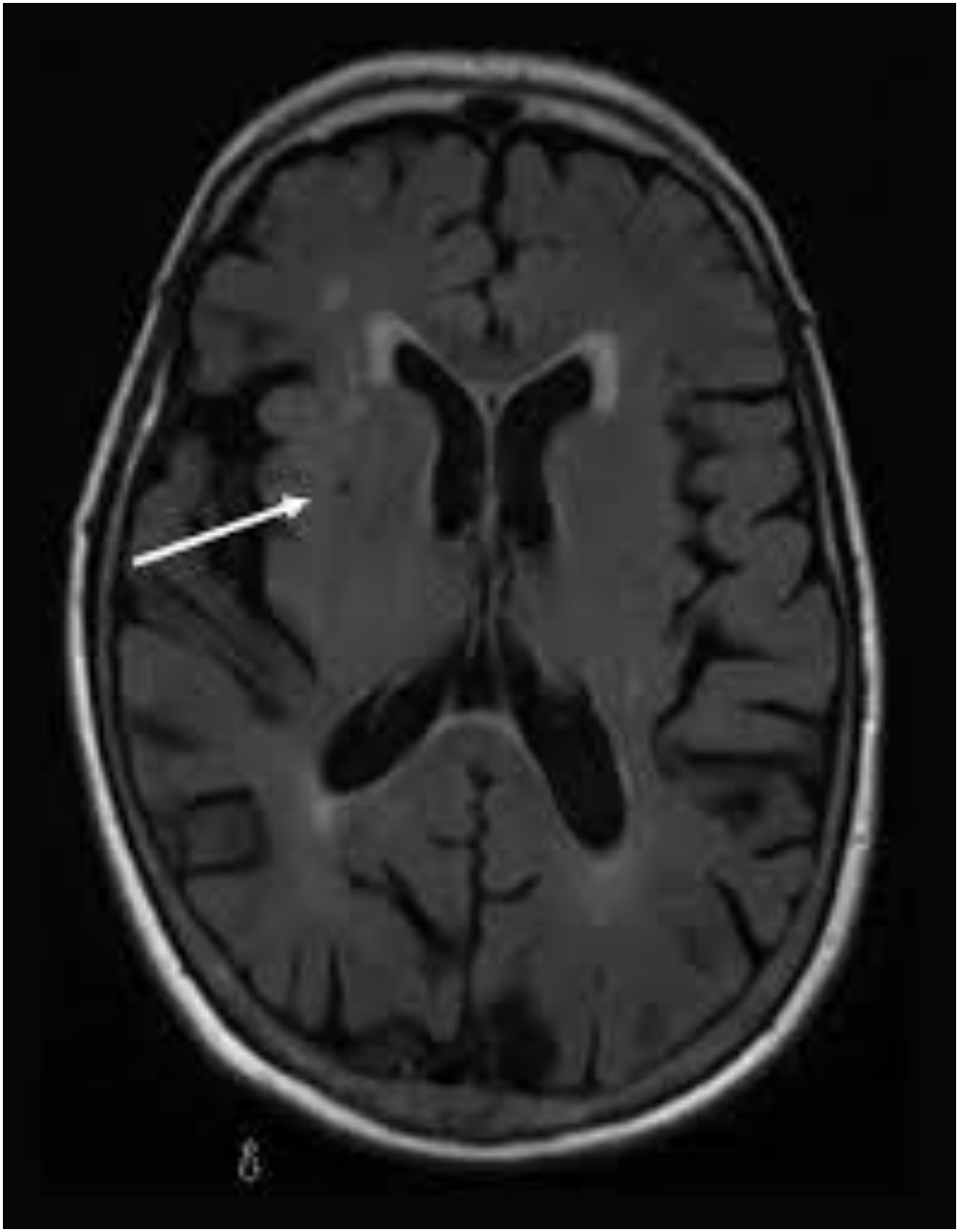
Side: A
25-10-2023
08:36

Rekvirent:	OAMV							
Dato: Prøvetidspunkt:	25/10 2023 11:20							
Komponent:							**Enhed**	**Ref.int.**
Hæmatologi								
B-Hæmoglobin(Fe)	10,5						mmol/l	**8,0-11,0**
B-Erythrocytter; vol.	92						fl	**80-100**
Ercs(B)-Hæmoglobin(Fe); stofk.	21,2						mmol/l	**19,0-22,3**
B-Leukocytter	**21,8***						10E9/l	**3,0-10,0**
B-Leukocytttype								
B-Neutrophilocytter	**13,40***						10E9/l	**1,50-7,50**
B-Eosinophilocytter	**0,00***						10E9/l	**0,04-0,50**
B-Basophilocytter	0,00						10E9/l	**< 0,20**
B-Lymphocytter	1,77						10E9/l	**1,00-3,50**
B-Monocytter	**0,97***						10E9/l	**0,20-0,80**
B-Thrombocytter	250						10E9/l	**120-400**
P-Folat	15,4						nmol/l	**5,0-30,0**
P-Cobalamin	517						pmol/l	**140-650**
Væske- og elektrolytbalance								
P-Natrium-ion	**148***						mmol/l	**136-146**
P-Kalium-ion	4,4						mmol/l	**3,3-4,7**
P-Albumin	**56***						g/l	**37-48**
P-Carbamid	6,5						mmol/l	**3,0-7,8**
P-Creatininium(enzymatisk)	**133***						µmol/l	**60-105**
S-Calcium-ion,pH 7,4	**1,38***						mmol/l	**1,19-1,29**
Nyre-Glomerulær filtration eGFR	**48***						ml/1.73mE2	**> 60**
Hæmostase								
P-Koagulationsfaktorer(II + VII + X)akt/no	1,07						arb.enh./l	**0,70-1,30**
P-Koagulationsfaktorer(II + VII + X) INR	0,9							
Organmarkører								
P-lactatdehydrogenase	181						U/l	**105-205**
P-Alanintransaminase	20						U/l	**10-70**
P-Basisk phosphatase	**219***						U/l	**35-105**
P-Bilirubiner	6						µmol/l	**< 20**
Metabolisme								
P(vB)-Glucose	**8,2**						mmol/l	

Endokrinologi								
Rekvisitionsnr:	965 5xxx							
Kommentarer:								
* = Udenfor reference interval f = Resultat ændret T = Terapeutisk intervaller						= obs resultater		
Jette Nielsen Tlf: 6541 1926/1924 FAM							**ENKELTSVAR** Side: B 25-10-2023 08:36	
Rekvirent:	OAMV							
Dato: Prøvetidspunkt:	25/10 2023 11:20							
Komponent:							**Enhed**	**Ref.int.**
S-Thyrotropin (TSH)	0,54						10E-3 int.enh/l	0,030-4,00
Immunologi og inflammation								
P-C reaktivt protein	423						mg/l	**< 10**
Andre undersøgelser								
Pt-Elektrocardiografi	Udført							
KMA-Uspecificerede analyser	Taget							
Rekvisitionsnr:	965 5xxx							
Kommentarer:								RP:F6
* = Udenfor reference interval f = Resultat ændret T = Terapeutisk intervaller						= obs resultater		




I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6



Appendix 9: Feedback to leaders with a list of trained skills, attention points and recommendations for the ward

16. september 2019

Kære afdeling FAM, SHS

Tak fordi vi måtte komme og træne med jeres personale.
Vi oplevede os meget velkomne og taget godt i mod.

Vi vil hermed gerne give en kort tilbagemelding til jer ift. de temaet vi har trænet og hvad vi anbefaler i fokuserer på i den kommende tid.

På baggrund af vores første observationer i jeres afdelingen har vi i scenarierne haft fokus på følgende punkter:

- Forstyrrelser af kollegaer
- Kommunikationsveje (ansigt-til-ansigt, cetrea, EPJ, telefon)
- Koordination af opgaver
- Situationsbevidsthed
- Team samarbejde
- Uddannelsesforpligtigelser

De overordnede fokus punkter for projektet er:

- Beslutningstagen
- Kommuniker effektivt
- Mobiliser tilgængelige ressourcer
- Situationsbevidsthed
- Teamwork
- Udøv lederskab og følgeskab

Vi anbefaler at I den kommende tid særligt fokuserer på følgende punkter:

- Kultur omkring mobiltelefonen
- Kultur omkring forstyrrelser
- Koordinering og prioritering af opgaver
- Situationsbevidsthed
- Uddannelsesforpligtelse og håndtering af disse

Vi ser frem til at besøge jer igen om en månedstid til fokus på transfer af kompetencerne der er trænet.

De bedste hilsner

Malte Lebahn & Lotte Abildgren

Appendix 10: Approvals from the Research Ethical Committee and the Region of Southern Denmark

From:	Christina Sølvsten Fly
To:	Lotte Abildgren
Cc:	Malte Lebahn-Hadidi
Subject:	Afgørelse: Anmeldelse til videnskabetisk komite - SimLEARN-projektet
Date:	4. oktober 2018 11:58:18

Kære Lotte og Malte.
De Videnskabsetiske Komitéer for Region Syddanmark har modtaget jeres forespørgsel om, hvorvidt jeres projekt er anmeldelsespligtigt i henhold til Komiteloven. Jeres henvendelse har fået sagsnummer 20182000-140.

Ud fra de foreliggende oplysninger har komitéen besluttet, at projektet **ikke** er anmeldelsespligtigt til det videnskabsetiske komitésystem, jf. § 14, stk. 1 i lov om videnskabsetisk behandling af sundhedsvidenskabelige forskningsprojekter (komiteloven).

Der er ved afgørelsen lagt vægt på, at der synes at være tale om et projekt, hvor de forsøgsrelaterede procedurer ikke kan anses som intervention i komitélovens forstand, som falder uden for rammerne af komitélovens definition af et anmeldelsespligtigt sundhedsvidenskabeligt forskningsprojekt.

I medfør af komitélovens § 14, stk. 2 skal spørgeskemaundersøgelser og sundhedsvidenskabelige registerforskningsprojekter kun anmeldes til det videnskabsetiske komitésystem, såfremt projektet omfatter menneskeligt biologisk materiale.

Såfremt et sundhedsvidenskabeligt forskningsprojekt skal falde inden for rammerne for anmeldelsespligtigt til komitésystemet, skal projektet, jævnfør retningslinjer fra National Videnskabsetisk Komité, både have et sundhedsvidenskabeligt formål og medføre en intervention: http://www.nvk.dk/forsker/naar-du-anmelder/hvilke-projekter-skal-jeg-anmelde.

Sagen er behandlet af formanden for Komité 1, institutleder, professor, læge, ph.d., MPM, Kirsten Ohm Kyvik.

Komiteens afgørelse kan, jf. komitelovens § 26, stk. 1, indbringes for National Videnskabsetisk Komite (NVK), senest 30 dage efter afgørelsen er modtaget. NVK kan, af hensyn til sikring af forsøgspersonernes rettigheder, behandle elementer af projektet, som ikke er omfattet af selve klagen.

Klagen skal indbringes elektronisk og ved brug af digital signatur og kryptering, hvis protokollen indeholder fortrolige oplysninger. Dette kan ske på adressen: dketik@dketik.dk

Klagen skal begrundes og være vedlagt kopi af den regionale videnskabsetiske komites afgørelse samt de dokumenter/oplysninger, som den regionale videnskabsetiske komite har truffet afgørelse på grundlag af.

Hvis afgørelsen påklages til NVK, bør der ikke foretages indholdsmæssige ændringer i projektmateriale, da projektet ellers vil blive sendt retur til komiteen til fornyet førsteinstansbehandling.

Venlig hilsen

Christina Sølvsten Fly
Administrativ koordinator
Kvalitet og Forskning, De Videnskabsetiske Komitéer for Region Syddanmark

E-mail: Christina.Soelvsten.Fly@rsyd.dk
Direkte: 76638221
Mobil: 29202252

logo

Regionshuset
Damhaven 12, 7100 Vejle
Hovednummer: 7663 1000
www.rsyd.dk

Fra: Lotte Abildgren
Sendt: 3. oktober 2018 09:40
Til: Videnskabsetiske Komité
Cc: Lotte Abildgren; Malte Lebahn
Emne: Anmeldelse til videnskabetisk komite - SimLEARN-projektet

Til De videnskabsetiske komiteer for Region Syddanmark

Vi fremsender hermed en forespørgsel om hvorvidt nedenstående forskningsprojektet, bestående af to ph.d.-studier, skal anmeldes:

Projekttitel
SimLEARN: Reduktion af utilsigtede hændelser gennem læringstransfer af non-technical skills
To ph.d.-studier af postgraduat sundhedspersonales non-technical skills før, under og efter in situ simulation med fokus på henholdsvis forbedringer i teamsamarbejde og medicinhåndtering.

Projektansvarlige:
Ph.d.-A: Lotte Abildgren, cand.cur., intensivsygeplejerske
Ph.d.-B: Malte Lebahn, cand.mag.

Vejledere:
● Ph.d.-A hovedvejleder og ph.d.-B projektvejleder: Lise Hounsgaard, ph.d., professor ved OPEN, Klinisk institut, Det Sundhedsvidenskabelige Fakultet, SDU & Docent, University College Lillebælt.
● Ph.d.-B hovedvejleder og ph.d.-A projektvejleder: Sune Vork Steffensen, ph.d., professor, centerleder ved Centre for Human Interactivity, Institut for Sprog og Kommunikation, SDU.
● Ph.d-A medvejleder: Palle Toft, professor og overlæge, ved Anæstesiologisk-Intensiv Afdeling V, Odense Universitetshospital.
● Ph.d-B medvejleder: Christian Backer Mogensen, ph.d., professor og overlæge, ved Akutcenter – FAM, Sygehus Sønderjylland.

Formål
Forskningsprojektet skal undersøge postgraduat sundhedspersonales

kommunikation, kognition og organisationskultur før, under og efter in situ simulationstræningsforløb (dvs. træning i de daglige kliniske lokaler). Hensigten er at skabe viden om, hvordan sundhedspersonalet overfører læring fra simulationskurser til deres kliniske praksis. Hovedfokus vil være på henholdsvis sundhedspersonalets medicinhåndtering (Malte Lebahn) og teamsamarbejde (Lotte Abildgren).

Datagenerering, informanter og placering
Data genereres gennem et etnografisk feltstudie og i forbindelse med simulationskurser. Data vil bestå af feltnoter, billeder og videomateriale der indsamles på to hospitaler i Region Syddanmark, hhv. Odense Universitetshospital og Aabenraa, Sygehus Sønderjylland. Specifikt hentes data fra fire forskellige hospitalsafdelinger med to specialer, hhv. intensiv og infektionsmedicin i Odense og intensiv og FAM i Aabenraa.

Forskningsprojektet studerer sundhedsteams i deres komplekse kliniske hverdag og inklusionskriteriet for de deltagende sundhedspersonaler i simulationstræningsforløbet er derfor givet af den eksisterende vagtplan. De to ph.d.-studerende vil følge sundhedspersonalet i den enkelte afdeling, deltagelsen vil udelukkende være af observationel art, de deltager således ikke i hverken pleje eller behandling. Observationerne dokumenteres både ved hjælp af noter og videomateriale.

Samtykke
Godkendelse indhentes indledningsvis fra deltagende hospitalsafdelingers øverste ledelse. Sundhedspersonale, patienter og pårørende informeres herefter verbalt og skriftligt samt gives mulighed for at stille spørgsmål til projektet med henblik på at kunne foretage informeret samtykke. De informeres yderligere om, at de ikke er forpligtet til at deltage og kan trække sig fra studiet på ethvert tidspunkt, uden at dette har negative konsekvenser for deres arbejde eller behandling. Alt identificerbart datamateriale anonymiseres, og anvendelse af genkendeligt materiale i offentlige præsentationer mv. sker alene efter gennemsyn og skriftlig aftale med de pågældende deltagere.

Etik
Forskningsprojektet følger gældende regler for videnskabsetik, herunder de etiske retningslinjer for sygeplejeforskning i Norden, Helsinki-deklarationen, The Nuremberg Code og Code of Federal Regulations. Projektet anmeldes til De videnskabsetiske Komitéer for Region Syddanmark og SDU (Institutional Review Board, IRB). Forskningsprojektet udføres efter reglerne i EU's Persondataforordning og Danish Code of Conduct for Research Integrity.

I er meget velkomne til at kontakte os for yderligere information.

Vores spørgsmål er, om projektet på baggrund af ovenstående informationer skal anmeldes til videnskabsetisk komite?

De bedste hilsner

Malte Lebahn & Lotte Abildgren

Malte Lebahn
cand.mag.
ph.d.studerende, Humaniora, SDU
lebahn@sdu.dk

Tlf. +45 2671 7420

Lotte Abildgren
cand.cur., intensivsygeplejerske
ph.d.studerende, Klinisk Institut, SDU
Lotte.Abildgren@rsyd.dk - www.ouh.dk
Tlf. +45 6541 4739

Anæstesiologisk-Intensiv Afdeling V
Odense Universitetshospital
J.B. Winsløws Vej 4, Indgang 5 Penthouse/2, 5000 Odense C

Lotte Abildgren
Anæstesiologisk Intensiv Afdeling V
OUH Odense Universitetshospital Svendborg
Sygehus

Region Syddanmark

Afdeling: Direktionssekretariatet
Kontaktperson: Elisabeth Eggersen
E-mail: Elisabeth.Eggersen@rsyd.dk
Direkte tlf. + 45 23 84 49 44

Dato: 04-04-2019
Journal nr. 19/14608

Vedrørende anmeldelse af:

SimLEARN: Reduktion af utilsigtede hændelser gennem læringstransfer af non-technical skills

Ovennævnte projekt/database indgår d. **04-04-2019** i Region Syddanmarks fortegnelse over behandling af personoplysninger i forbindelse med forskning.

Det fremgår af anmeldelsen, at du er ansvarlig for projektets/databasens oplysninger.
Behandlingen af oplysningerne ønskes påbegyndt pr. **04-04-2019** og forventes at ophøre **28-02-2025.**

Oplysningerne vil blive behandlet på følgende adresse: **Odense Universitetshospital, J. B. Winsløws Vej 4, 5000 Odense C.**

Specifikationer

Projektets formål er: **Målet at udvikle et generisk koncept for, hvordan hospitalers patientsikkerhed kan optimeres ved at nedbringe antallet af utilsigtede hændelser gennem in situ simulationstræning for sundhedspersonalet. Specifikt vurderes personalets potentiale for læring i relation til teamsamarbejde samt overførsel af denne læring til handlekompetence i klinisk praksis.**
Formålet med studiet er således at udvikle grundlæggende, tværfaglig viden om, hvordan sundhedspersonalet overfører ikke tekniske færdigheder fra simulationstræning til handlekompetence i klinisk praksis og at forstå hvordan personalets teamsamarbejde ændres som følge af in situ simulationstræning.

Der vil blive behandlet følgende kategorier af registrerede persongrupper:
A) Postgraduat sundhedspersonale ansat i en af de fire afdelinger hvor projektet kører. De 4 afdelinger er FAM og Intensiv, Aabenraa, SHS & Q og ITA3, Odense, OUH
B) Patienter der er omkring sundhedspersonen i fbm. observationerne (patient og pårørendes oplevelser af personalet anvendelse af ikke tekniske færdigheder).

C) Pårørende der er omkring sundhedspersonen i fbm. observationerne (patient og pårørendes oplevelser af personalet anvendelse af ikke tekniske færdigheder).

Der vil blive behandlet følgende kategorier af personoplysninger:
ad A) demografiske data – alder, køn, uddannelse(evt. specialuddannelse), uddannelsesår, ansættelsesår på den pågældende afdeling. Udsagn om de observerede patienters sundhedstilstand, diagnoser, indlæggelsesårsager, behandlinger etc.
ad B) udsagn fra patienter om patientens sundhedstilstand, diagnoser, indlæggelsesårsager, behandlinger etc samt om oplevelsen af personalet anvendes af human factors (samarbejde, kommunkation etc.).
ad C) udsagn fra pårørende om patientens sundhedstilstand, diagnoser, indlæggelsesårsager, behandlinger etc samt om oplevelsen af personalet anvendes af human factors (samarbejde, kommunkation etc.).

TILLADELSE

Der meddeles hermed på vegne af Region Syddanmark tilladelse til projektets/databasens gennemførelse.

Region Syddanmark fastsætter i forbindelse med tilladelsen nedenstående vilkår:

Generelle vilkår

Tilladelsen gælder indtil: 28-02-2025.
Ved tilladelsens udløb skal du særligt være opmærksom på følgende:

Hvis du ikke inden denne dato har fået tilladelsen forlænget, går Region Syddanmark ud fra, at projektet/databasen er afsluttet, og at personoplysningerne er slettet, anonymiseret, tilintetgjort eller overført til arkiv, jf. nedenstående vilkår vedrørende projektets/databasens afslutning.

Region Syddanmark gør samtidig opmærksom på, at al behandling (herunder også opbevaring) af personoplysninger efter tilladelsens udløb er en overtrædelse af databeskyttelsesforordningen.

1. **Lotte Abildgren, Intensivsygeplejerske, cand.cur., ph.d.studerende, Anæstesiologisk Intensiv Afdeling V, Odense Universitetshospital OUH** i Region Syddanmark er, som projekt-/databaseansvarlig på vegne af Region Syddanmark som dataansvarlig, ansvarlig for overholdelsen af de fastsatte vilkår.

2. Såfremt ovenfornævnte projekt-/databaseansvarlige ikke længere er tilknyttet det sygehus, hvorfra behandlingen af personoplysningerne sker, skal en ny projekt-/databaseansvarlig udnævnes. Dette skal meddeles Region Syddanmark som dataansvarlig myndighed.

3. Oplysningerne må kun anvendes til brug for projektets/databasens gennemførelse.

4. Behandling af personoplysninger må kun foretages af den projekt-/databaseansvarlige eller på foranledning af denne. Behandling af personoplysninger må kun foretages på vegne af Region Syddanmark som den dataansvarlige og på dennes ansvar.

5. Enhver (herunder ansatte i Region Syddanmark), der foretager behandling af projektets/databasens oplysninger, skal være bekendt med de fastsatte vilkår.

6. De fastsatte vilkår skal tillige iagttages ved behandling af personoplysninger, der foretages af databehandler.

7. Ved brug af databehandler indgås databehandleraftale mellem Region Syddanmark og databehandleren.

8. Lokaler, der benyttes til opbevaring og behandling af projektets/databasens oplysninger, skal være indrettet med henblik på at forhindre uvedkommende adgang.

9. Behandling af oplysninger skal tilrettelægges således, at oplysningerne ikke hændeligt eller ulovligt tilintetgøres, fortabes eller forringes. Der skal endvidere foretages den fornødne kontrol for at sikre, at der ikke behandles urigtige eller vildledende oplysninger. Urigtige eller vildledende oplysninger eller oplysninger, som er behandlet i strid med lovgivning eller disse vilkår, skal berigtiges eller slettes.

10. Oplysninger må ikke opbevares på en måde, der giver mulighed for at identificere de registrerede i et længere tidsrum end det, der er nødvendigt af hensyn til projektets/databasens gennemførelse.

11. En eventuel offentliggørelse af undersøgelsens resultater må ikke ske på en sådan måde, at det er muligt at identificere enkeltpersoner.

12. Eventuelle vilkår, der fastsættes efter anden lovgivning, forudsættes overholdt.

Elektroniske oplysninger

13. Adgangen til projekt-/databasedata må kun finde sted ved benyttelse af et personligt fortroligt password. Kun personer, der er beskæftiget med eller har et andet sagligt formål til projektet/databasen må tildeles et password til projektets/databasens data. Passwordet skal afgrænses således, at den enkelte projektdeltager alene har rettigheder til de funktioner, der

er relevante for denne, fx forespørge, inddatere eller slette personoplysninger. Udformning og udskiftning af password bør følge Region Syddanmarks "Instrukser for brug af it".

14. Hvert halve år skal det kontrolleres, at projektdeltagerne har de korrekte rettigheder.

15. Der skal foretages registrering af alle afviste adgangsforsøg. Hvis der inden for en fastsat periode er registreret et nærmere fastsat antal på hinanden følgende afviste adgangsforsøg fra samme arbejdsstation eller med samme brugeridentifikation skal der blokeres for yderligere forsøg. Der skal følges op på afviste adgangsforsøg.

16. Der skal foretages logning af alle anvendelser af personoplysninger i forbindelse med projektet/databasen. Loggen skal mindst indeholde oplysning om tidspunkt, bruger, type af anvendelse og angivelse af den person, de anvendte oplysninger vedrørte eller det anvendte søgekriterium.

17. Såfremt identifikationsoplysninger enten er krypterede, eller erstattet med et id-nummer, skal loggen alene indeholde oplysninger om bruger og tidspunktet for behandlingen (se, gemme, søge, opdatere m.v.)

18. Loggen skal opbevares i 6 måneder, hvorefter den skal slettes. Ved særligt behov kan loggen opbevares i op til 5 år.

19. Nøglefiler – krypteringsnøgle, kodenøgle m.v. – skal opbevares forsvarligt og adskilt fra personoplysningerne.

20. Ved behov for adgang til projektets/databasens data uden for Region Syddanmarks lokation/netværk, skal dette ske via enten en VPN-forbindelse eller en Citrix-forbindelse.

    Såfremt projektets/databasens data opbevares i et eksternt system hos en databehandler, og der er behov for adgang til disse data uden for databehandlerens lokation/netværk, skal dette også ske via enten en VPN-forbindelse eller en Citrix-forbindelse.

21. Ved overførsel af personhenførbare oplysninger via Internet eller andet eksternt netværk uden for Region Syddanmark skal der træffes de fornødne sikkerhedsforanstaltninger mod, at oplysningerne kommer til uvedkommendes kendskab. Oplysningerne skal som minimum være forsvarligt krypteret under hele transmissionen. Overføres data inden for Region Syddanmarks netværk sker overførslen krypteret/sikkert.

22. Data må ikke opbevares lokalt på fx C-drevet på pc'er eller USB-nøgler. Dog kan der ske sikkerhedskopiering af data til udtagelige lagringsmedier. Disse skal opbevares forsvarligt aflåst og således, at uvedkommende ikke kan få adgang til oplysningerne.

Manuelle oplysninger

23. Manuelt projekt-/databasemateriale, udskrifter, fejl- og kontrollister, m.v., der direkte eller indirekte kan henføres til bestemte personer, skal opbevares forsvarligt aflåst og på en sådan måde, at uvedkommende ikke kan gøre sig bekendt med indholdet.

24. Manuelt projekt-/databasemateriale skal slettes, når det ikke længere er relevant for projektet/databasen, dog senest ved projektets/databasens afslutning **28-02-2025**.

Oplysningspligt over for den registrerede

25. Hvis der skal indsamles oplysninger hos den registrerede (ved interview, spørgeskema, klinisk eller paraklinisk undersøgelse, behandling, observation m.v.) skal der uddeles/fremsendes nærmere information om projektet/databasen. Den registrerede skal heri oplyses om den dataansvarliges navn, formålet med projektet/databasen, at det er frivilligt at deltage, og at et samtykke til deltagelse til enhver tid kan trækkes tilbage.

Indsigtsret

26. Den registrerede har ikke krav på indsigt i de oplysninger, der behandles om den pågældende.

Videregivelse

27. Videregivelse af personhenførbare oplysninger til tredjepart må kun ske til brug i andet statistisk eller videnskabeligt øjemed, der ikke er uforeneligt med det formål, hvortil dataene oprindeligt er indsamlet.

28. Videregivelse til tredjepart må kun ske efter forudgående tilladelse fra enten Region Syddanmark eller Datatilsynet, jf. databeskyttelsesloven § 10, stk. 3. Region Syddanmark eller Datatilsynet kan som godkendende myndighed stille nærmere vilkår for videregivelsen samt for modtagerens behandling af oplysningerne. Ansøgning om tilladelse til videregivelse af data til tredjepart sker via den informationssikkerhed@rsyd.dk.

Ændringer i projektet/databasen

29. Væsentlige ændringer i projektet/databasen skal anmeldes/meddeles til den lokale kontaktperson (som ændring af eksisterende anmeldelse).

30. Ændring af tidspunktet for projektets/databasens afslutning skal altid anmeldes/meddeles til den lokale kontaktperson.

Ved projektets/databasens afslutning

31. Senest ved projektets/databasens afslutning skal oplysningerne slettes, anonymiseres eller tilintetgøres, således at det efterfølgende ikke er muligt at identificere enkeltpersoner, der indgår i undersøgelsen.

32. Alternativt kan oplysningerne overføres til videre opbevaring i Statens Arkiver (herunder Dansk Dataarkiv) efter arkivlovens regler.

33. Sletning af oplysninger fra elektroniske medier skal ske på en sådan måde, at oplysningerne ikke kan genetableres. Der bør i denne forbindelse tages kontakt til din lokale it-afdeling, jf. instruks for brug af it i Region Syddanmark.

Ovenstående vilkår er gældende indtil videre. Region Syddanmark forbeholder sig senere at tage vilkårene op til revision, hvis der skulle vise sig behov for det.

Region Syddanmark gør opmærksom på, at denne tilladelse alene er en tilladelse til at behandle personoplysninger i forbindelse med projektets/databasens gennemførelse. Tilladelsen indebærer således ikke en forpligtelse for myndigheder, virksomheder m.v. til at udlevere eventuelle oplysninger til dig til brug for projektet/databasen.

Advarsel – ved brug af Excel, PowerPoint m.v.

Den dataansvarlige skal til enhver tid sikre sig, at dokumenter og andre præsentationer, som publiceres eller på anden måde gøres tilgængelig for andre på internettet, usb-nøgle eller på andet elektronisk medie, ikke indeholder personoplysninger.

Der skal vises særlig agtpågivenhed i forbindelse med brug af grafiske præsentationer i Excel og PowerPoint, da de uforvarende kan indeholde indlejrede persondata i form af regneark, tabeller mv. Præsentationer, der gøres tilgængelig på internettet, skal derfor omformateres til Portable Digital Format (PDF), da dette fjerner eventuelle indlejrede Excel-tabeller.

Venlig hilsen

Elisabeth Eggersen
Juridisk Studentermedhjælper

Damhaven 12, 7100 Vejle
Tlf. 7663 1000
http://www.regionsyddanmark.dk

12. Papers

I. Abildgren, L., Lebahn-Hadidi, M., Mogensen, C. B., Toft, P., Nielsen, A. B., Frandsen, T. F., Steffensen, S. V. and Hounsgaard, L., (2022). The effectiveness of improving healthcare teams' human factor skills using simulation-based training: a systematic review, Advances in Simulation. 7, 1, 18 p., 12.

II. Abildgren, L., Lebahn-Hadidi, M., Mogensen, C. B., Toft, P., Steffensen, S. V. and Hounsgaard, L., (2023). Transfer human factor skills from simulation-based training to competency in clinical practice – a demonstration of a hybrid method for assessing transfer of learning. International Journal of Healthcare Simulation, 1-13.

III. Abildgren, L., Lebahn-Hadidi, M., Mogensen, C. B., Toft, P., Steffensen, S. V. and Hounsgaard, L., From simulation-based training to competency in clinical practice – Findings from a qualitative investigation of transferring human factor skills. (re-submitted dec. 2023)

A. Lebahn-Hadidi, M., Abildgren, L., Hounsgaard, L. and Steffensen, S. V., (2023). Integrating cognitive ethnography and phenomenology: rethinking the study of patient safety in healthcare organisations, Phenomenology and the Cognitive Sciences. 22, 1, p. 193–215.

B. Lebahn-Hadidi, M., Abildgren, L., Hounsgaard, L., Mogensen, C. B. and Steffensen, S. V., Beyond *No Interruptions Zones* in the medicine room: Patient safety through human factors training. (**Manuscript**)

Paper I

Advances in Simulation

RESEARCH Open Access

The effectiveness of improving healthcare teams' human factor skills using simulation-based training: a systematic review

Lotte Abildgren[1,2,3*], Malte Lebahn-Hadidi[3,4], Christian Backer Mogensen[3], Palle Toft[1,5], Anders Bo Nielsen[2,5,6], Tove Faber Frandsen[7], Sune Vork Steffensen[4,8,9,10] and Lise Hounsgaard[2,11,12]

Abstract

Background: Simulation-based training used to train healthcare teams' skills and improve clinical practice has evolved 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 healthcare teams' human factor skills.

Method: A review protocol outlining the study was registered in PROSPERO. Using the PRISMA guidelines, the systematic search was conducted on September 28th, 2021, in eight major scientific databases. Three independent reviewers assessed title and abstract screening; full texts were evaluated by one reviewer. Content analysis was used to evaluate 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) Training human factor skills in qualified healthcare teams; (2) assessment of human factor skills; (3) combined teaching methods, and (4) retention and transfer of human factor skills. Unfortunately, the human factor skills assessments are variable in the literature, affecting the power of the result.

Conclusion: Simulation-based training is a successful learning tool to improve qualified healthcare teams' human factor skills. Human factor skills are not innate and appear to be trainable similar to technical skills, based on the findings of this review. 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 healthcare team, In-hospital

*Correspondence: lotte.abildgren@rsyd.dk
[3] Emergency Research Unit, Hospital Sønderjylland, University Hospital of Southern Denmark, Odense, Denmark
Full list of author information is available at the end of the article

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 increased 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, and 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 non-routine, complex environments due to interactions between humans and the systems in which they work. These interactions are modifiable due to learning skills (e.g. leadership-followership, decision-making and coordination) rather than lack of knowledge [6–9]. The medical simulation and patient safety literature most often refer to these aspects as non-technical skills, crisis resource management or interpersonal relations [9–14]. These common concepts are too limited, however, since they specifically define competence in terms of what is lacking (non-technical skills), what it is for (crises resource management) or interaction between people (interpersonal relations). The comprehensive concept of human factors includes broader aspects of human interaction, including social skills, cognitive skills and decision-making. It emphasises how the environment, the organisation and human psychology interact [15, 16]. Based on this reflection, this article will use human factors skills (HFS) as the terminology for the skills in focus. Patient safety reports and root cause analysis indicate that adverse events occur in interactions between technology, organisation and human factors, and adverse events are about understanding the interactions among humans and other elements of a system, including social and cognitive structures [1, 2, 17]. An example is the relocation of healthcare personnel from their everyday work to COVID-19 units [18]. This challenged even highly competent personnel and might have caused an increased number of human errors. Personnel had to adapt to unfamiliar technical and cognitive procedures and new surroundings, complications, colleagues and workflows. The Danish Patient Safety Database shows a 32% increase in reported adverse events in 2020 [19], with a peak at the beginning of the COVID-19 pandemic.

[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).

Research indicates that simulation-based training (SBT) is a safe and effective tool to develop and increase competencies in healthcare [20]. However, existing reviews focus on technical skills (TS), self-confidence, self-efficacy and the effectiveness of SBT for unqualified healthcare students [21–24] and develop unqualified healthcare students' HFS [25, 26]. SBT has been found to refine qualified healthcare teams' TS, self-efficacy and confidence [24, 27]. Existing studies of qualified healthcare teams' HFS focus on developing curricula, specific settings or situations or testing new evaluation or rating instruments [28–32]. Buljac-Samardzic et al. [33] explored interventions that improved team effectiveness and concluded that SBT enhances teamwork, though interventions studies were limited to specific situations, settings and outcomes. As mentioned, HFS are crucial to reducing adverse events [34], but evidence concerning the effectiveness of SBT to refine qualified healthcare teams' use of HFS is sparse. There is a need for additional knowledge about the effectiveness of developing HFS in qualified healthcare teams 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 teams' human factor skills.

Methods

The AMSTAR 2-criteria (A MeaSurement Tool to Assess systematic Reviews) were used to prepare the review [35]. The review report follows the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement [36]. Details of the protocol were registered in the International Prospective Register of Systematic Reviews (PROSPERO) [37] (record ID: CRD42021118670).

Search strategy

SPICE (Setting, Perspective/population, Intervention, Comparison and Evaluation) [38], an alternative to the qualitative conceptualising model PICO [39], 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 healthcare 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.

Table 1 Inclusion and exclusion criteria

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.

Boolean operators were used, 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. Search histories are available in Supplement A.

Study selection and critical appraisal

Covidence [40], a screening and data extraction tool, was used in the study selection process. Except for reviews, research protocols and conference abstracts, all study design and publication types were included. Authors LA, MLH and ABN individually performed the title and abstract screening using a standardised pre-piloted guide of inclusion and exclusion criteria (Table 1). Communication with patients or relatives and virtual reality were excluded as the focus was on the performance of qualified healthcare teams. Studies using role-play were excluded because some team members role-play it does not resemble the everyday practice where every team member interacts due to the situation and competencies. The role-playing personnel has a role and a script and therefore only acts if given a significant task.

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) [41], Mixed Methods Appraisal Tool (MMAT) [42] or Critical Appraisal of a Survey [43]. 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 [44, 45] was used to assess the effectiveness. Content analysis is a systematic and objective research method that enables qualitative and quantitative content analysis. Stemler's inductive technique was used to analyse the content. From open coding to creating themes and abstraction [44]. The following topics framed the content analysis: *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.

Ethical consideration

Ethical approval was not deemed necessary because data was from previously published studies, but the study meet(s) the claims of the Helsinki Declaration [46].

Results

The initial search identified 34,846 publications, representing 19,767 unique studies, after removing 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 (Fig. 1).

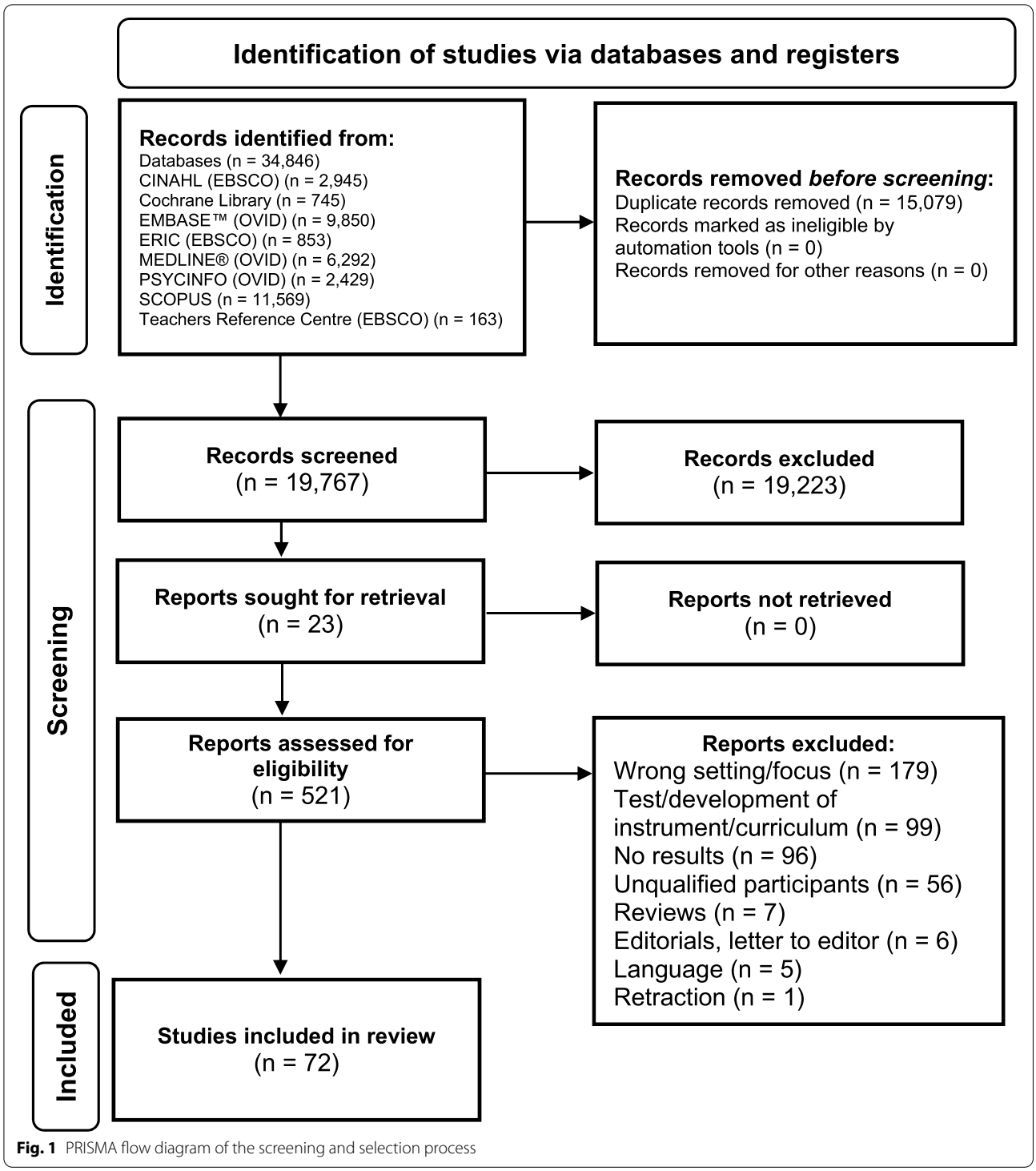
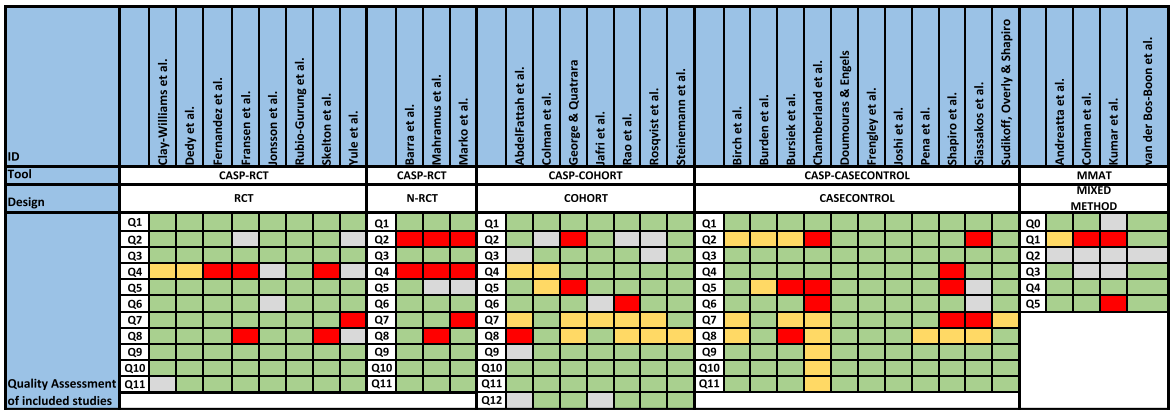


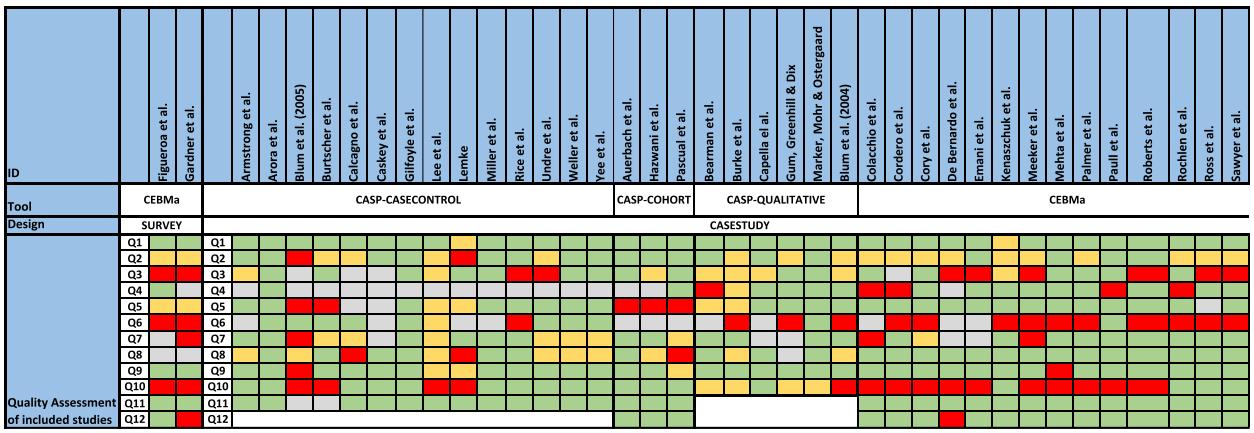
Fig. 1 PRISMA flow diagram of the screening and selection process

Result of quality assessment of included studies

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

Table 2 Quality assessment of 72 studies included in a systematic review of The effectiveness of improving healthcare teams' human factor skills using simulation-based training. Green = Yes, Red = No, Grey = Can't tell, Yellow = Not relevant, Q = Question





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 standalone ($n = 51$), 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 trained one or more 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 13 different disciplines participated. Mono-disciplinary SBT was seen in 20 studies; physicians ($n = 18$) were primarily trained separately from other qualified personnel. An extracted summary of included studies is shown in Table 3, and the whole summary is available in Supplement B.

Content analysis

The content analysis identified four recurring themes: (1) Training HFS in qualified teams, (2) assessment of

Table 3 Extracted summary of studies included in a systematic review of The effectiveness of improving healthcare teams' human factor skills using simulation-based training. The full summary of included studies is available in Supplement B

ID 1 st Author Year of publication Country of study	Study design	Participants (N=) Medical speciality (Monodisciplinary (MO) /Multidisciplinary (MU))	Training type (In situ (I), Center (C) / (Un)Formal (U/F) / (Un)Announced (U/A))	Intervention (Lecture (L), Workshop (W), Simulation (S) (HFS /TS))	Improvement Self Assessed (SA) Rated (R) Test (T) Tool or Skill trained	Quality (Validity (Hi-Me-Lo), Reliability(Hi-Me-Lo))	Keyfindings
Clay-Williams 2013 Australia	**RCT**	N=60 Obstetrics (MU)	C / U / A	S (HFS) / L - S (HFS) / L (HFS)	**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 (HFS)	**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 (HFS)	**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 (HFS)	**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 (HFS)	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 (HFS - 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 (HFS)	**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 (HFS)	**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.
ID 1 st Author Year of publication Country of study	**Study design**	**Participants** (N=) **Medical speciality** (Monodisciplinary (MO) /Multidisciplinary (MU))	**Training type** (In situ (I), Center (C) / (Un)Formal (U/F) / (Un)Announced (U/A))	**Intervention** (Lecture (L), Workshop (W), Simulation (S) (HFS /TS))	**Improvement** Self Assessed (SA) Rated (R) Test (T) Tool or Skill trained	**Quality** (Validity (Hi-Me-Lo), Reliability(Hi-Me-Lo))	**Keyfindings**
Barra 2018 Italy	**NRCT**	N=15 Anasthesiology (MO)	C / F / A	L - S - W (HFS - 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 (HFS)	**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 (HFS - 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 (HFS)	**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 (HFS)	**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 (HFS)	**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 (HFS - 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 (HFS)	**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.

Table 3 (continued)

ID 1 st Author Year of publication Country of study	Study design	Participants (N=) Medical speciality (Monodisciplinary (MO) /Multidisciplinary (MU))	Training type (In situ (I), Center (C) / (Un)Formal (U/F) / (Un)Announced (U/A))	Intervention (Lecture (L), Workshop (W), Simulation (S) (HFS /TS))	Improvement Self Assessed (SA) Rated (R) Test (T) Tool or Skill trained	Quality (Validity (Hi-Me-Lo), Reliability(Hi-Me-Lo))	Keyfindings
Birch 2007 United Kingdom	**Case control**	N=36 Obstetrics (MU)	I / N / A	L - S (HFS)	**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 (HFS, 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 (HFS)	**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 (HFS - 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 (HFS)	**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 (HFS - 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 (HFS)	**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 (HFS)	**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.
ID 1 st Author Year of publication Country of study	**Study design**	**Participants** (N=) **Medical speciality** (Monodisciplinary (MO) /Multidisciplinary (MU))	**Training type** (In situ (I), Center (C) / (Un)Formal (U/F) / (Un)Announced (U/A))	**Intervention** (Lecture (L), Workshop (W), Simulation (S) (HFS /TS))	**Improvement** Self Assessed (SA) Rated (R) Test (T) Tool or Skill trained	**Quality** (Validity (Hi-Me-Lo), Reliability(Hi-Me-Lo))	**Keyfindings**
Shapiro 2004 America	**Case control**	N=16 Emergency medicine (MU)	C+I / U / A+U	L - S (HFS)	**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 (HFS)	**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 (HFS - 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 (HFS - 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 (HFS)	**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 = Teamperformance 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 (HFS - 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 (HFS - 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 (HFS - TS)	**SA** Communication P=<0.05 **SA** Leadership P=<0.05 **SA** Taskmanagement 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.

Table 3 (continued)

ID 1 st Author Year of publication Country of study	Study design	Participants (N=) Medical speciality (Monodisciplinary (MO) /Multidisciplinary (MU))	Training type (In situ (I), Center (C) / (Un)Formal (U/F) / (Un)Announced (U/A))	Intervention (Lecture (L), Workshop (W), Simulation (S) (HFS /TS))	Improvement Self Assessed (SA) Rated (R) Test (T) Tool or Skill trained	Quality (Validity (Hi-Me-Lo), Reliability(Hi-Me-Lo))	Keyfindings
Gardner 2008 America	**Survey**	N=58 Obstetrics (MU)	C / U / A	S (HFS - 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 (HFS - 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 (HFS - 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 (HFS - 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 (HFS - 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 (HFS)	**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 (HFS)	**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 (HFS)	**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
ID 1 st Author Year of publication Country of study	**Study design**	**Participants** (N=) **Medical speciality** (Monodisciplinary (MO) /Multidisciplinary (MU))	**Training type** (In situ (I), Center (C) / (Un)Formal (U/F) / (Un)Announced (U/A))	**Intervention** (Lecture (L), Workshop (W), Simulation (S) (HFS /TS))	**Improvement** Self Assessed (SA) Rated (R) Test (T) Tool or Skill trained	**Quality** (Validity (Hi-Me-Lo), Reliability(Hi-Me-Lo))	**Keyfindings**
Burtscher 2011 Switzerland	**Case study**	N=30 Anasthesiology (MU)	I / U / A	S (HFS)	**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 (HFS - 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 (HFS)	**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 (HFS - 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 (HFS)	**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 (HFS - 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 (HFS)	**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 (HFS - 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

Table 3 (continued)

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Emani 2018 America	**Case study**	N=23 Intensive Care - Pediatrics (MU)	I / U / A	L - S (HFS)	**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 (HFS - 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 (HFS - 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 (HFS - 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 (HFS - 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 (HFS)	**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 (HFS - 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 (HFS - 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 (HFS)	**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.
ID 1 st Author Year of publication Country of study	**Study design**	**Participants** (N=) **Medical speciality** (Monodisciplinary (MO) /Multidisciplinary (MU))	**Training type** (In situ (I), Center (C) / (Un)Formal (U/F) / (Un)Announced (U/A))	**Intervention** (Lecture (L), Workshop (W), Simulation (S) (HFS /TS))	**Improvement** Self Assessed (SA) Rated (R) Test (T) Tool or Skill trained	**Quality** (Validity (Hi-Me-Lo), Reliability(Hi-Me-Lo))	**Keyfindings**
Meeker 2018 America	**Case study**	N=36 Obstetric (MU)	C + I / U / A	S (HFS - 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 (HFS - 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 (HFS)	**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 (HFS)	**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 (HFS)	**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 (HFS)	**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 (HFS)	**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.

Table 3 (continued)

ID 1 st Author Year of publication Country of study	Study design	Participants (N=) Medical speciality (Monodisciplinary (MO) /Multidisciplinary (MU))	Training type (In situ (I), Center (C) / (Un)Formal (U/F) / (Un)Announced (U/A))	Intervention (Lecture (L), Workshop (W), Simulation (S) (HFS /TS))	Improvement Self Assessed (SA) Rated (R) Test (T) Tool or Skill trained	Quality (Validity (Hi-Me-Lo), Reliability(Hi-Me-Lo))	Keyfindings
Roberts 2013 America	**Case study**	N=45 Surgery (MU)	I / U / A	L - S (HFS)	**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 3W - lost retention
Rochlen 2019 America	**Case study**	N=27 Surgery (MU)	I / U / A	S (HFS)	**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 (HFS)	**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 (HFS)	**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 (HFS - 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 (HFS)	**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 (HFS)	**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 (HFS)	**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.

HFS, (3) combined teaching methods and (4) retention and transfer of skills. These themes will be elaborated on below.

Training HFS in qualified healthcare teams

The vast majority ($n = 65$) of the studies concluded that SBT could develop qualified teams using HFS. In two-thirds of the studies, HFS as the sole focus of the training were seen and associated with enhanced effectiveness [13, 47–73]. These studies were mainly conducted in simulation centres, with smaller teams ($n = 2$–8 members), and the SBT-courses were announced. It is a significant result that HFS usually are trained together with TS, and when trained on its own, it is taught in centres rather than in situ and minor teams. Most of the 27 studies ($n = 22$) used validated assessment methods and performed debriefing ($n = 24$) immediately after every SBT scenario. Nevertheless, Emani et al. [60] and Jafri et al. [74] show a correlation between TS scores and HFS scores, which emphasises that the effect of SBT is evident when HFS is trained solely in combination with other competencies. Studies of multi-disciplinary training ($n = 47$) [13, 48, 53, 56, 58–64, 66–69, 71–102] were generally associated with greater effectiveness than mono-disciplinary training, perhaps because multi-disciplinary training better reflects everyday clinical practice.

Three studies showed potential effect [71, 93, 99], 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 [85, 98]; 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 [68, 74, 93, 100] 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 [13, 56, 60, 61, 72, 74–77, 80, 81, 83, 86, 88, 90, 91, 98, 102–109]. In total, 3251 of the participants were trained in acute paediatric scenarios. HFS during resuscitation ($n = 20$) was the second most trained situation [10, 13, 49, 52, 53, 59, 61, 62, 65, 72, 76, 78, 87, 89–91, 101, 104–108, 110], involving 1887 personnel. This illustrates that acute and high-intensity situations are the main focus of SBT concerning teams' HFS. Common to these training situations are available algorithms and checklists of the TS or HFS (e.g. acute caesarean, cardiopulmonary resuscitation, Crisis Resource Management), which facilitate a form of corrective actions. However, compliance with checklists and training algorithms does not cover the dynamics of HFS. Checklists and algorithms are task-oriented (check

of rhythm, request read-back) that differ from the nature of HFS, which are social and cognitive processes within environmental and organisational frames. These task-oriented approaches increase the risk of changing the focus from the all-around focus to the tasks themselves. This could be why the focus on TS overtakes the focus on HFS in some of the studies, for instance, in Arora et al. and Siassakos et al. [99, 111].

This demonstrates that SBT increases the HFS among qualified teams, but due to the lack of high-quality studies using similar assessment tools, the level of effectiveness was not established.

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 [49, 55, 58, 61, 64, 65, 68, 71, 75, 78, 80, 81, 84, 85, 87, 89, 95, 96, 98, 99, 103, 107, 111–115]. Assessment methods ($n = 51$) spanned quantitative, qualitative and mixed methods, validated and non-validated methods, rating 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 concluded 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 [10, 47–49, 51–56, 59, 60, 62, 64, 65, 72–77, 79, 80, 83, 87, 90, 100, 101, 104, 107, 108, 114, 116]. 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, as mentioned, 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 specific action or treatment [13, 51, 61, 83, 89]. For instance, the increased time could also be due to improvements in the TS and not the HFS. HFS training associated with specific behaviour markers were the most successful assessment [10, 49, 54, 59, 65, 72, 73, 79, 101, 102, 114]. Five tools generally inspired the methods used: crisis resource management [117, 118]; Kirkpatrick Model: Four Levels of Learning Evaluation [119]; Mayo High-Performance Teamwork Scale [120]; Ottawa Global Rating Scale [121]; and TeamSTEPPS® [122].

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 [47, 53, 57, 60, 65, 67, 68, 72, 78, 81, 85, 88, 93, 95, 97, 98, 108, 116], whereas 13 studies used self-assessment as the only method [82–84, 87, 92, 94, 100, 102, 105, 107, 109, 110, 112]. 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 [123, 124]. Some studies ($n = 21$) used video recording and blinded assessors [47, 48, 54, 58, 60, 61, 63, 66, 70, 71, 74, 76, 89, 91, 98, 99, 103, 106, 108, 111, 114], 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 [10, 49–51, 53, 57, 59, 62–65, 67, 68, 72, 73, 75, 77–79, 81, 85, 93, 96, 101, 107, 115, 125].

The most frequently trained HFS were communication, leadership and teamwork. The specification of the trained HFS were described in various ways. Eleven studies [10, 13, 54, 69, 71, 98, 100, 101, 103, 114, 115] 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 [49, 57, 58, 63, 73, 76, 79, 85, 88, 89, 102, 106, 108, 109, 112]. Communication and teamwork were the two most trained HFS.

Communication and teamwork are both broad terms. Communication and teamwork are not isolated and unequivocal tasks; they depend on and influence each other, like most HFS. The purpose of outlining and dividing the tasks into behaviour markers is to simplify a complex clinical situation, i.e. highlight easily recognisable behaviour for the participants, making it easier to acquire and develop skills [118, 126]. 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 determine and report the effect of training when the focus is on general terms such as communication and teamwork without a definition or level of detail. It is not possible to distinguish between teamwork/communication and cognition. While communication and teamwork are often immediately recognisable and valid interpretations for training personnel, they are high-level concepts difficult to rate to assessors. Maybe because you know it when you experience it but not always when you see it. 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 facts, due to the increased transparency [10, 13, 47, 48, 50, 52–55, 65–67, 69–72, 74, 75, 77, 78, 96–98, 100, 101, 103, 107, 114, 116].

They combined teaching methods

Significant effects on HFS were observed in 32 studies that combined SBT with didactics and workshops, compared to 12 that just trained SBT. The impact on qualified teams' use of HFS was evident, regardless of whether SBT was combined with didactics and workshops or 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 from TS training resulted in the most significant improvements in the teams' use of HFS.

The studies that combined HFS and TS training tended to focus more on TS. For instance, Burden et al. and Siassakos et al. covered the results of HFS training with only a few sentences [99, 125], and Hazwani et al. asserted that a refined time to first medicine infusion in cardiopulmonary resuscitation training was because of an enhancement in teamwork [13].

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 patient outcome. Transfer of enhanced HFS are identified in 20 studies, but in two of these [79, 104], the authors identify transfer due to developed TS. The researchers argue that improved TS and time decrease in accomplishing the procedure are due to an increase in HFS skills. Roberts et al. find a transfer of HFS, but with low retention over time [66]. The transfer of HFS was measured as a decrease in adverse events and improved patient outcomes in six studies [49, 59, 79, 95, 97, 104].

Discussion

This systematic review demonstrates that SBT is a successful learning tool to improve HFS in-hospital healthcare settings. Unfortunately, we were unable to show the effect level due to the use of all the different assessment tools. More research is required to increase knowledge about the transfer of competencies to daily clinical practice, examining why many studies use non-validated assessment strategies and the barriers to training HFS. While HFS are widely taught, there are gaps in the literature regarding efficacy assessment. There is a need for more long-term studies and studies about how we translate assessment of skills to clinical work. However, there is a lack of knowledge about the 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.

Although this review revealed support for training HFS in the clinical setting using SBT, there is a lack of agreement on which tools are best to assess HFS. There are gaps in the literature regarding the assessment of the HFS. More research and consensus on how we assess HFS is needed before the level of effectiveness can be estimated. All assessment methods in SBT should be supported by valid evidence. Several instruments are designed to evaluate the effect of HFS skills through SBT. Still, 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, making comparison challenging. This raises new questions about training HFS and future directions for research.

Cognition is an emergent property of the situation and environment. Knowledge, perceived facts, understanding and predictions within each team member's mind interact with displayed information, cues and devices in the environment to affect decision-making and situational awareness. Recurrent exposure to these factors can lead to personal, team and institutional learning. Furthermore, the environment can be modified and redesigned to support the team's improved performance and safety. Cognition is thus an individual and shared mental process within the team in all situations [127–129]. Therefore, it is essential to add social, cognitive, environmental and technology markers to the teaching/learning situations if the goal is to enhance the teams' HFS or redesign the environment to increase patient safety. Nevertheless, 43% of the studies show significant effectiveness in refining HFS using SBT, and 92% show some effectiveness. This means that, regardless of multiple assessment methods, this review offers a significant or improved effect of HFS using SBT, and the outcome was relatively homogeneous—HFS improves using SBT. A meta-analysis by Salas et al. concludes that team training is a useful intervention with a moderate, positive effect on team processes [130]. This adds to the reliability of the present review. Therefore, the differences among the methods in the included studies are not a weakness of the research but rather a strength for the results. On the other hand, it makes the results inconsistent because of the lack of comparability. More research and effort towards a consensus on assessing human factor skills in the medical simulation society are requested.

The review also demonstrates that studies in which HFS was trained alone had a more significant effect than those 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 an add-on to develop procedures, algorithms and associated

TS in specific settings. This may be for several reasons: everyday clinical situations involve both HFS and TS, trained together, or 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 [34]. 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 essential in reducing adverse events within healthcare and need to be qualified and trained just as seriously as technical skills and clinical procedures.

The high amount of studies from acute and high-intensity situations and the paediatric speciality shows that there is awareness of the need for training qualified personnel, that SBT is not only for the students and novices. The training mostly around algorithms is unclear and could be an exciting focus in future research. Nevertheless, the results also show that qualified teams mostly train situations where life is at stake. However, adverse events not only happens in highly acute situations but also in slow situations such as medication administration [131], receiving and transferring patients [132, 133] and development of sepsis [134]—all situations where teams interact. If healthcare teams are trained in everyday care, it might reflect everyday clinical practice and prevent or reduce future adverse events.

An interesting result is that the training teams mostly were 2–5 members, although critical care teams are more prominent in numerous places in the world. The reasons for this are unclear, but possible explanations include the expense of SBT and a high turnover of qualified healthcare personnel [135]. Moreover, the participants are often volunteers, and the likely absence of volunteers can explain.

It is important to understand learning holistically, integrating the individual, brain, body and surroundings [136]. All levels of education involve both physical and cognitive stimulations, and if the content is too vast, the learning decreases. The results suggest that focusing exclusively on HFS in SBT can lead to a deeper awareness of HFS's effect on patient safety among teams and, possibly consequently larger learning potential. However, further research will have to study to what degree HFS transfers to competence in clinical practice. The results show that SBT for HFS alone, combined with didactics and workshops may lead to the most significant improvement in teams' HFS. This is substantiated by Maturana's theory of suitable disturbances [137, 138], 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 massive for participants to engage with. However, the link to clinical practice is still underdeveloped.

Conclusion

This systematic review demonstrates a strong indication that SBT is an effective learning tool to improve HFS in-hospital healthcare settings. However, HFS are inconsistently described, interpreted, taught and assessed and the lack of real-world assessment or follow-up makes the transfer to everyday practice challenging. This systematic review does not entirely answer if SBT improves HFS in qualified healthcare teams. Still, it highlights the gaps in the literature and underpins the necessity of increasing the focus on HFS or routine care in SBT to improve outcomes. There is a need for more long-term studies and studies about how we translate assessment of skills to clinical work. However, there is a lack of knowledge about the 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. Healthcare, in general, must support the necessity and significance for HFS. Otherwise, the HFS will not be effectively transferred to everyday practice. Also, design issues such as positioning of the equipment, cognitive aids and process changes are needed to support ideal human performance such as not relying on memory or complex decision-making in complex time-pressed situations. More research is required to increase knowledge about the transfer of competencies to daily clinical practice, examining why many studies use non-validated assessment strategies and the barriers to training HFS.

Limitations

A few limitations of this review need to be highlighted. Firstly, three authors screened a vast 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 influences the internal validity and reliability. The bias was sought to be minimised by bringing any doubts about selected studies to the broader author group. Nevertheless, the intercoder reliability is inevitably affected when human coders are used in content analysis [139]. Secondly, the Hawthorne effect (behaviour alteration simply because HFS were studied) represents a possible bias [140]. 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. Moreover, it is essential to point out that 20 of the included studies were from an emergency medicine setting, which can have influenced the results. A review focusing on HFS, in general, could have elucidated studies from other settings. Finally, the results may be affected 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 teams' HFS. SBT is an effective learning tool for use with novices and experts, and with unqualified or qualified personnel. A change of focus is recommended for healthcare providers to train emergencies or rare situations and 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 teams' can develop their HFS significantly through SBT. Using SBT to train the healthcare personnel for everyday clinical practice are essential. Firstly, because the everyday routine takes up most of the performance tasks in the hospitals, the personnel are constantly in different forms of teamwork. Secondly, as learned from Safety II, it is necessary to enhance the ability to succeed (reduce adverse events) under varying conditions [141]. Thirdly, healthcare personnel are constantly interchangeably with new demands (e.g. professional, environmental and technical) to the personnel. Finally, yet significantly, the high degree of personnel turnover in healthcare affects the quality of care, a quality that the use of continual SBT can increase. If the personnel's HFS are capable in everyday practice, they will in all probability be in acute and high-intensity situations.

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. Instead, they are generic and essential in reducing adverse events within healthcare and demands an increased focus on systematic multidisciplinary training of HFS among healthcare teams.

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.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s41077-022-00207-2.

Additional file 1. Supplement A–Searches.

Additional file 2. Supplement B–Results summary.

Acknowledgements

The authors declare no conflict of interest but disclose receipt of the following financial support for the research and authorship of this article: Anaesthesiology and Critical Care Department, Odense University Hospital; Hospital Sønderjylland; OPEN, Clinical Research, University of Southern Denmark; and Centre for Human Interactivity, Department of Language and Communication, University of Southern Denmark.

Authors' contributions

LA drafted the manuscript. LA, ABN and MLH conducted the title and abstract selection. LA conducted the full-text reading and the interpretation of data. All authors critically revised the manuscript and the authors read and approved the final manuscript.

Funding

Odense University Hospital; Hospital Sønderjylland; University of Southern Denmark.

Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

[1]Anesthesiology and Intensive Care Unit, Odense University Hospital, Odense, Denmark. [2]OPEN, Open Patient data Explorative Network, Odense University Hospital/Department of Clinical Research, University of Southern Denmark, Odense, Denmark. [3]Emergency Research Unit, Hospital Sønderjylland, University Hospital of Southern Denmark, Odense, Denmark. [4]Centre for Human Interactivity, Department of Language and Communication, University of Southern Denmark, Odense, Denmark. [5]Department of Clinical Research, University of Southern Denmark, Odense, Denmark. [6]SimC, Regional Center for Technical Simulation, Region of Southern Denmark, Odense, Denmark. [7]Department of Design and Communication, University of Southern Denmark, Kolding, Denmark. [8]Danish Institute for Advanced Study, University of Southern Denmark, Odense, Denmark. [9]Center for Ecolinguistics, South China Agricultural University, Guangzhou, People's Republic of China. [10]College

of International Studies, Southwest University, Chongqing, People's Republic of China. [11]Institute of Nursing & Health Science, Ilisimartusarfik, University of Greenland, Nuuk, Greenland. [12]Center for Mental Health Nursing and Health Research (CPS), Mental Health Services, Region of Southern Denmark, University of Southern Denmark, Odense, Denmark.

Received: 21 September 2021 Accepted: 5 April 2022
Published online: 07 May 2022

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Publisher's Note

Paper II

ORIGINAL RESEARCH

Transfer of human factor skills from simulation-based training to competency in clinical practice – a demonstration of a hybrid method for assessing transfer of learning

Lotte Abildgren[1,2,3,4,5,6], Malte Lebahn-Hadidi[7], Christian Backer Mogensen[3], Palle Toft[1,6], Sune Vork Steffensen[4,5,8,9,10], Lise Hounsgaard[2,11]

[1]*Anesthesiology and Intensive Care Department, Odense University Hospital, Odense, Denmark*
[2]*OPEN, Open Patient data Explorative Network, Odense University Hospital/Department of Clinical Research, University of Southern Denmark, Odense, Denmark*
[3]*Emergency Research Department, Hospital Sønderjylland, University Hospital of Southern Denmark, Odense, Denmark*
[4]*CFPK, Centre for Research in Patient Communication, Odense University Hospital, Odense, Denmark*
[5]*Centre for Human Interactivity, Department of Language and Communication, University of Southern Denmark, Odense, Denmark*
[6]*Department of Clinical Research, University of Southern Denmark, Odense, Denmark*
[7]*Centre for Shared Decision Making, Lillebælt Hospital, Vejle, Denmark*
[8]*Danish Institute for Advanced Study, University of Southern Denmark, Odense, Denmark*
[9]*Center for Ecolinguistics, South China Agricultural University, Guangzhou, China*
[10]*College of International Studies, Southwest University, Chongqing, China*
[11]*Institute of Nursing & Health Science, Ilisimatusarfik, University of Greenland, Nuuk, Greenland*

Corresponding author: Lotte Abildgren, lotte.abildgren@rsyd.dk

https://ijohs.com/article/doi/10.54531/GORE1210

ABSTRACT

Introduction Increasingly more resources are being used internationally in training and educating qualified healthcare personnel due to high personnel flow and rapid development within technology, care and treatment. Consequently, transferring learning from simulation-based training to competency in clinical practice is an essential question for healthcare faculty and management. Nevertheless, there is no established method for assessing if transfer occurs. This article aims to demonstrate how a hybrid method can explore transfer of learning from a simulation-based course to competency in clinical practice. **Methods** The hybrid method consists of a phenomenological–hermeneutic Ricœur-inspired analytical approach and a Cognitive Event Analysis of ethnographic data from a healthcare setting. **Discussion** It is argued that this hybrid method can gain awareness of behavioural changes following a simulation-based training course and how transfer happens. It is concluded that the hybrid method can provide insights into complex actions and constitutes a systematic and detailed approach to capturing transfer of human factor skills from simulation-based training to competency in critical practice. This research is the first step in developing a tool of transfer.

What this study adds

- Demonstrates a hybrid method that might make it possible to describe, explain and understand transfer from simulation-based training to competency in everyday clinical practice.
- A hybrid method with a Ricœur-inspired analysis and a Cognitive Event Analysis (RI-CEA) is time consuming and needs further development. This work can be the groundwork for further research in capturing transfer of learning.
- The RI-CEA method is the first step in developing a tool for improving transfer of human factor skills.

Introduction

Internationally, simulation-based training (SBT) is increasingly used in healthcare to train qualified personnel's technical and human factor skills1 (HFS) [1]. Consequently, there is a need to understand if and how HFS transfers from SBT to competency2 [2] in everyday clinical practice.

This article argues that a hybrid method is needed to clarify how knowledge and competencies are transferred from SBT into competency in clinical practice. Due to the complexity of tracking changes inb human behaviour, such a hybrid method must comprise at least (1) a theoretical framework that integrates social, psychological and cognitive aspects of behaviour; (2) methods for describing, understanding and explaining how HFS can become clinical competency; and (3) a factual investigation into how HFS is taught and adapted into complex clinical practice. This article proposes that combining a broad theoretical framework and hybridity of methods can provide insights into the effectiveness of SBT in improving healthcare personnel's HFS performance in clinical practice.

A new way of analysing ethnographic data from a Danish healthcare setting is presented with a hybrid of both a phenomenological–hermeneutic approach of *being in the world* (Ricœur) [3] and a cognitive ethnographic approach to track the conception and execution of tasks in cognitive systems (Hutchins) [4]. A hybrid method that can gain insight into how transfer of learning occurs in practice through specific descriptions of cognitive events and validated interpretations of similar events.

A recent systematic review [5] reveals that methods for assessing HFS in healthcare SBT are varied and inadequate and that HFS is often trained in interaction with technical skills training. Abildgren et al. show that when HFS is taught simultaneously with technical skills, HFS often becomes a secondary focus to medical knowledge (e.g. diagnosis, procedures and treatment), and technical skills become preferred learning objectives. Furthermore, when SBT courses emphasise HFS, it is often done through reductive checklists and acronyms (e.g. A–E principles, SBAR), and HFS is often codified as technical-related skills (e.g. behaviour markers: *asking for timeout*, *taking the leadership*, *delegating tasks*) to make them visible for monitoring. The conflation of technical skills with HFS adds further challenges to assessing transfer [5].

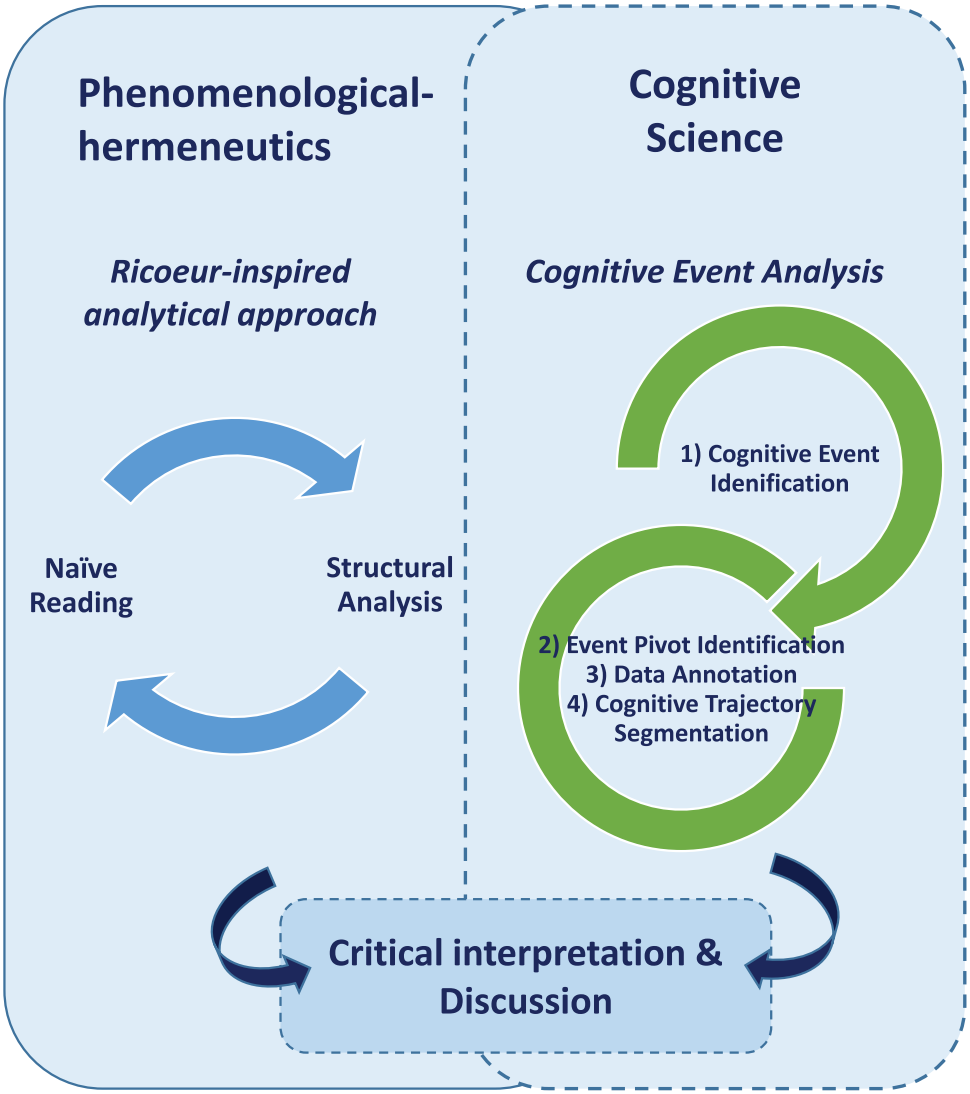
Research on SBT has established that technical skills improve professional performance and bring novices to a higher performance level sooner than if they had to learn the same skill through apprenticeship [6–8]. However, it needs to be determined if SBT of HFS is beneficial to the same degree. The lack of knowledge on HFS training is potentially due to the absence of concrete methods for monitoring transfer of HFS after SBT or the difference between HFS and technical skills. Monitoring potential improvements in HFS is more complex than monitoring technical skills. Furthermore, cognitive, social, interactive and situational factors are often not interactionally visible nor easily quantifiable. Therefore, reporting on these elements demands a divided awareness and aligned perception of the HFS within the assessors [9,10].

Researchers [11–15] have explored HFS by assessing behaviour and behaviour changes among healthcare personnel using observational studies combined with different assessment methods. These studies typically focus on the performance progress within the simulation scenarios, immediately before and after SBT, assessed by pre-and post-tests (knowledge), pre-and post-scenario (following algorithms or acronyms), behaviour makers or numbers of adverse events (patient safety). The weakness of such approaches is the need to track how HFS training transfers to competency in daily practice. Similarly, research establishes that adding knowledge only sometimes leads to new competency in everyday practice [16,17]. Knowing is not the same as performing. Humans are living organisms comprehending as they act and vice versa [18]. Consequently, to provide evidence of the effectiveness of SBT in improving HFS, there is a need for a method that describes, understands and explains how transfer of HFS from SBT to competency happens. The existing methods are either limited to describing or explaining.

Aim

This article demonstrates a hybrid method containing a first- and third-person perspective. The hybrid comprises identifying, understanding, describing and explaining transfer of HFS into actual clinical competency. The aim is to demonstrate how the hybrid method can capture how transfer happens. The hybrid method can contribute to understanding how the participants transfer HFS from SBT to competency in everyday clinical practice. The approach (visualised in Figure 1), with both its Ricœur-inspired analysis (RIA) and Cognitive Event Analysis (CEA) of ethnographic data (abbreviated RI-CEA), illustrates how research in SBT on HFS can benefit from methods other than the typical quantitative and descriptive methods.

Figure 1: The hybrid method RI-CEA, a phenomenological–hermeneutic approach combined with a cognitive science approach



The SimLEARN case study

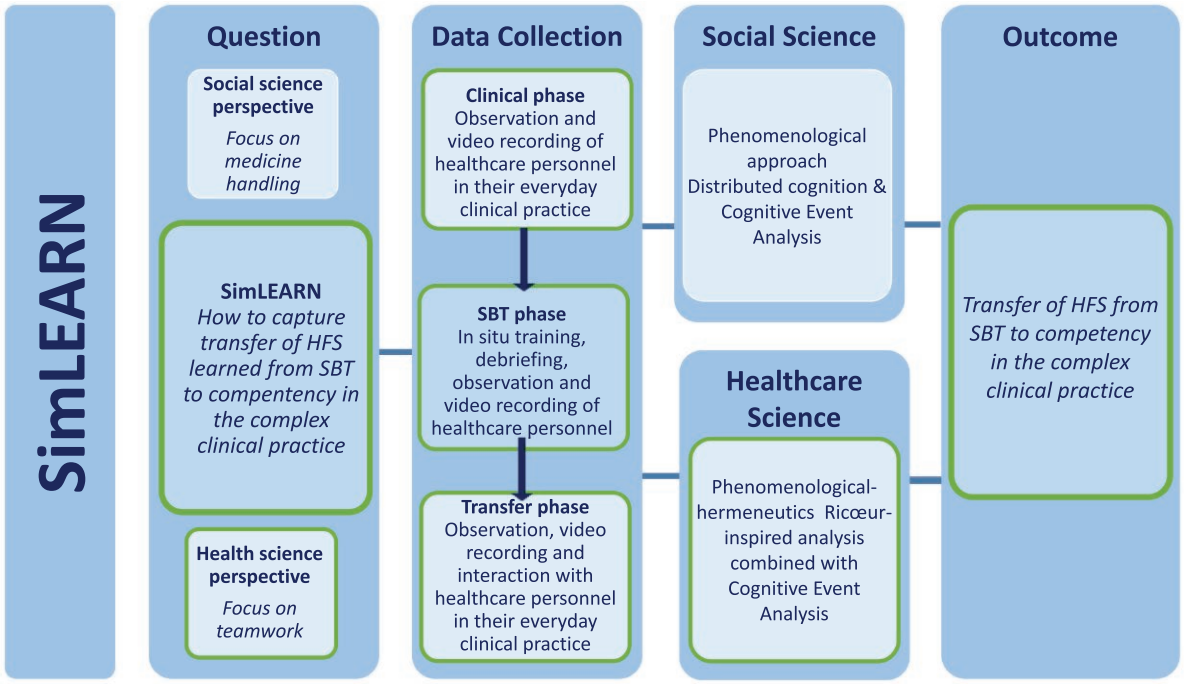
This article presents the hybrid method used in analysing data from a health science angle (Figure 2, the green path). The study is a health scientific substudy to SimLEARN. SimLEARN is a double PhD study with a social science angle [19] and a health science angle. SimLEARN explores how qualified in-hospital healthcare personnel transfers HFS learned from SBT to competency in everyday clinical practice at two Danish hospitals. Danish public hospitals are teaching hospitals and continuously receive newly educated healthcare personnel. SimLEARN's joint data collection consists of ethnographic studies [20,21] of qualified healthcare personnel before, during and after an interdisciplinary in situ SBT course and followed the design shown in Figure 2. The researchers shadowed healthcare personnel with cameras. Five doctors and 12 nurses were shadowed in the clinical phase, and 4 nurses in the transfer phase. Other healthcare personnel were shadowed when they joined work with the ones shadowed. A total of 45 healthcare personnel participated in the SBT course, including doctors, nurses, nurse assistants and students; the researchers shadowed their training and debriefing with cameras.

Through ethnographic examples, it is demonstrated how RI-CEA deliver insights into transfer of HFS from SBT courses into the clinical every day.

The Danish Data Protection Agency (ID 19/14608) and the Ethical Board of the Region of Southern Denmark (ID 20182000-140) approved the study.

The SBT course intervention in the SimLEARN study consists of introductory information meetings and a screencast about HFS to all personnel in the clinical departments before the data collection. Then 8 days of SBT and an online after-course participant evaluation survey. Each SBT day consists of three 10–20 minutes of in situ training (scenarios) at the participating hospital departments. First, a scenario about medicine room teamwork and then two patient-focused scenarios about teamwork and communication. After each scenario, a 25–30-minute debriefing [22,23] by external facilitators. The participants are volunteers at-work healthcare personnel from the duty schedule selected to match an authentic competence combination with assistance from the ward heads on the training day. All personnel can opt to decline participation, and participants give informed consent.

Figure 2: SimLEARN's project design



The ethnographic data include a diverse group of clinical personnel: doctors, nurses, physiotherapists, radiologists, nurse assistants, medical students, nursing students, technicians and secretaries.

Phenomenological–hermeneutic approach

The chosen qualitative and phenomenological–hermeneutic frame is based on the French philosopher Jean-Paul Ricœur, who combined phenomenology with critical hermeneutics. Ricœur's work bridges different philosophical positions (originating from, for example, Aristotle, Heidegger, Wittgenstein, Gadamer, Popper and Marcel) by synthesising parts into a critical phenomenological–hermeneutic philosophy [24,25].

The initial analytical approach of RI-CEA is inspired by a Ricœur-inspired approach to interpreting ways of *being in the world* [26–31], meaning the subjective experience of individuals and their comprehension of the lived life. The approach is created with reference to Ricœur's writings on language, reflection and text comprehension. Healthcare researchers have extended Ricœur's philosophy for analysing narratives, language, experiences, interviews and ethnographic data [26,27,30,32,33]. In short, humans are affected by situations and orient themselves as part of those situations (instead of behaving rationally under universal rules), which becomes their lived experience and existence in the world [3].

Observing video sequences and reading field notes as part of the RI-CEA method corresponds to how Ricœur views texts or narratives in the sense that the video sequences have *left* the original field and the participants with meaning to interpret. This resembles Ricœurs' claim that a text *leaves* the author's intentions. Thus, the object of study becomes the shared meaning of the video or text rather than the original intentions of the author or participants in the video. The researcher then *listens* to the meaning of the text and remains open to new details in video sequences or field notes for understanding, which emerge in *front of the text* [34,35]. Opening up the video or text through intuitive listening adds a first-person researcher's perspective on the data and grounds the research in the interpretation process by reclaiming the field, feelings, senses and thoughts that have escaped the researcher.

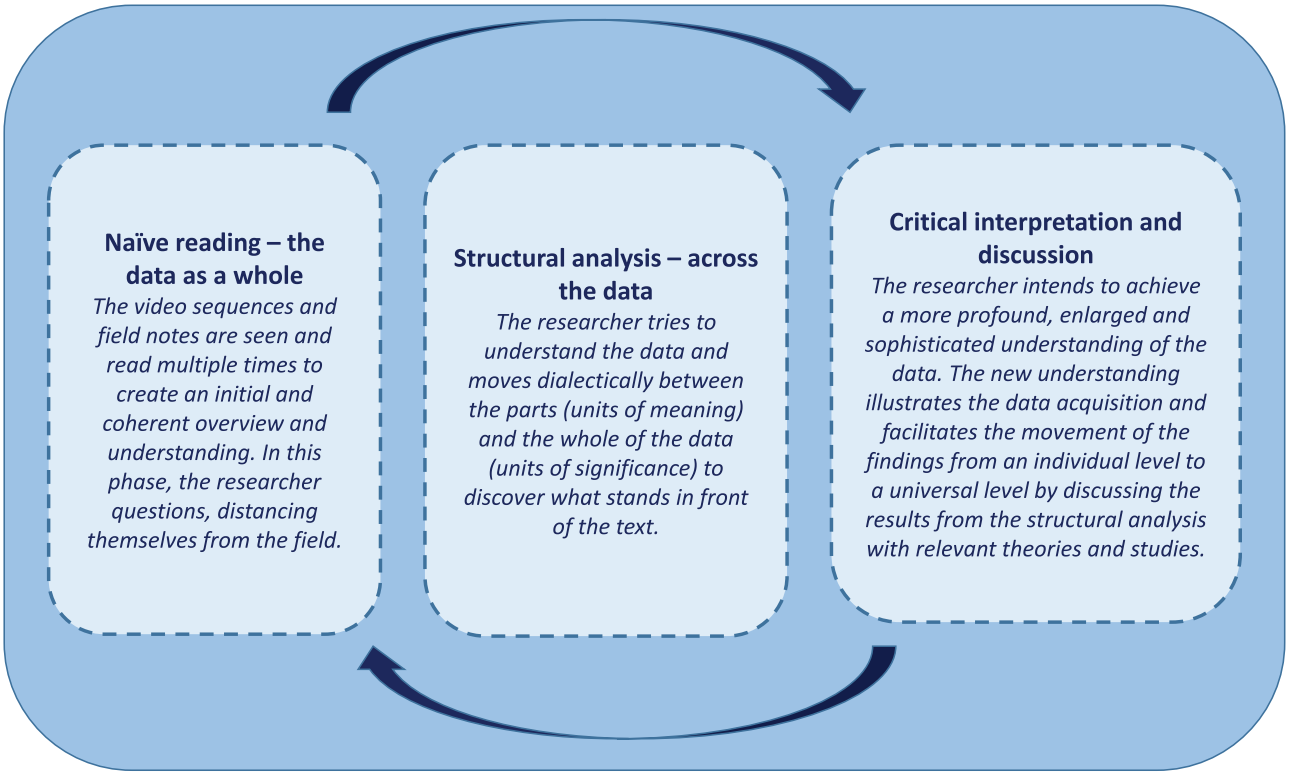
As shown in Figure 3, RIA is carried out on three levels: (1) naïve reading, where the researcher notes ideas, thoughts and impressions; (2) structural analysis; and (3) critical interpretation and discussion [26,30]. The analytical process is a dialectic process moving in a hermeneutical helix between naïve reading, structural analysis, and critical interpretation and discussion. This dialectic process between parts and the whole provides an enlarged, profound and sophisticated understanding of the participants' transformation of HFS.

Cognitive Science and Cognitive Event Analysis

The RI-CEA method's second analytical approach is CEA. CEA is a method with roots in cognitive science, specifically cognitive ethnography and distributed cognition [4]. Cognitive science explores thinking processes and aims to understand peoples' thinking and behaviour by examining human tasks [36,37]. Distributed cognition is a theory with interdisciplinary roots but with a phenomenological understanding of the human as embedded in an ecology of brain, body, environment and social interactions [4,38,39]. The primary hypothesis is that cognitive processes are distributed across brain, body, environment and over time [40]. Hence, cognition is not reducible to neural function but rather distributed in a network of relations [41].

CEA is an interactivity-based method to explore cognitive processes and closely examine the bodily and inter-bodily dynamics of movements, gestures, symbols and activities. CEA builds on the thinking of Hutchins, Järviletho,

Figure 3: The Ricœur-inspired analytical process showing the dialectic movement between the whole and the parts



Steffensen and others [4,41–44]. CEA makes it possible to *zoom* in and out on the organisational domain and to explore the real-time dynamics of human behaviour, where sense-making is investigated as coordination between agent(s) and an environment extended in time and space. CEA studies human cognition by focusing on bodily and inter-bodily dynamics using ethnographic video data [39]. The starting point of the CEA analysis is to identify the cognitive result (i.e. the outcome of a given cognitive process) and work backwards from this to gain insight into what caused or conditioned this result, thus gaining an understanding of the cognitive system and the cognitive trajectory [42]. To do so, CEA follows five steps:

1) **Cognitive event identification**: *Identifying a cognitive event to further inquiry. The event is defined as a change in the person–environment system from the observer's point of view, for example, activity of significance for the research question. The event is the bringing forth of the cognitive result.*
2) **Event pivot identification**: *Critical transition point(s) is revealed by identifying the emergence of the cognitive result and the causes and conditions that brought it forth.*
3) **Data annotation**: *The researchers annotate the data based on two independent questions: Which annotation categories does one select? And how fine-grained should the annotation be?*
4) **Cognitive trajectory segmentation**: *The researcher segments the video sequence into functionally or behaviourally defined phases by identifying annotation patterns. Having established behaviourally distinct patterns in different segments, these segments can be interpreted from a functional point of view.*
5) **Cognitive trajectory analysis**: *Finally, an interpretation of specific segments is completed based on the annotations and segmentations. The analysis identifies and explains the conditions and constraints that led to the specific cognitive results* [42].

Analysis

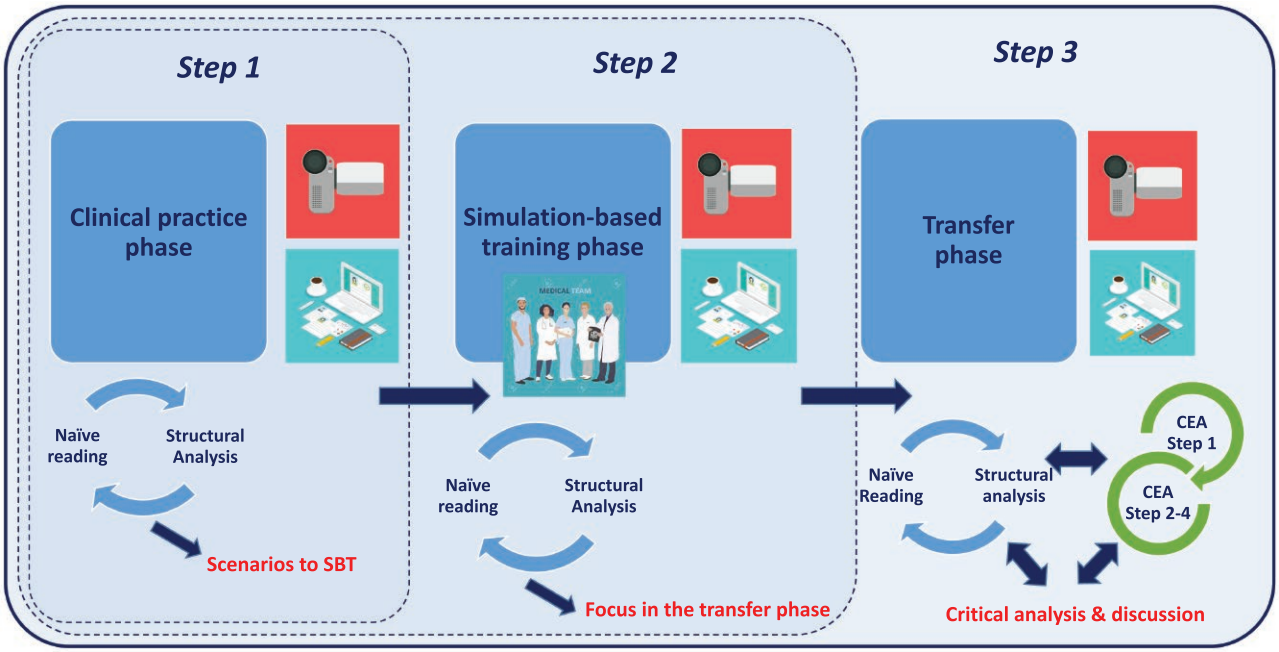
The study is divided into three steps, as shown in Figure 4. Step 1 – *Clinical practice phase*: It comprises ethnographic fieldwork of the qualified healthcare personnel's HFS in the everyday. These findings' initial analysis led to the content of the training scenarios in step 2. Step 2 – *SBT phase*: It comprises ethnographic fieldwork during an in situ SBT course in the included departments. The incipient analysis in step 2 led to the ethnographic focus of step 3. Step 3 – *Transfer phase*: The ethnographic fieldwork of the qualified healthcare personnel's use of HFS in their practice after participating in the SBT. The ethnographic fieldwork resulted in approximately 110 hours of video data. Finally, a compiled analysis of the overall data is conducted.

Ricœur-inspired analysis

Clinical practice phase – Ricœur-inspired analysis

The clinical phase comprises 2 days of ethnographic fieldwork in each participating department (Step 1, Figure 4). After the data collection, a naïve of video and field notes reading is conducted. Thoughts, spontaneous ideas, hypotheses and discussions between the two data-collecting researchers are noted and validated in the back-and-forth movement between the naïve reading and structural analysis (Figure 5a). In the structural analysis, one of the phenomena that kept appearing was different types of interruptions, which became a unit of

Figure 4: The SimLEARNS analytical process



meaning. This phenomenon was marked in the data every time it occurred. Figure 5a shows the deduced units of meaning (video descriptions, quotes or field notes), units of significance (what emerged *in front of the text*) and emerging themes from the analytical process (from the data to a theme).

The data suggest that personnel is interrupted often, although the types of interruption vary. The results of this initial analysis inspire the SBT scenarios, which are tailored for each participating department. The scenarios feature situations where, for example, interruptions happened, and HFS are needed for the personnel.

Simulation-based training phase – Ricœur-inspired analysis

The SBT phase contains 2 days of SBT in all the participating departments, 8 in total. Each SBT day comprises three clinical scenarios, each followed by a debriefing (step 2, Figure 4).

After the SBT, a naïve reading and structure analysis of this phase's data are conducted. In the naïve reading, all the data from the SBT phase are watched, read, revisited and reflected upon. Across the data, the personnel reflects on actions and responses to interruptions during the SBT, which become a unit of meaning. These reflections and reactions are marked in the data every time they occur. In the debriefing, the personnel discusses how interruptions in their workday result in stress, forgetting things, potential adverse events and changing their plans for the workday several times, among other outcomes.

The structural analysis opens a new understanding of how interruptions affect the personnel's work. Figure 5b shows examples of the naïve readings *units of meaning* towards *units of significance* and a new understanding after the structural analysis. Data suggest again, both in the scenarios and in the debriefings, that interruptions have a strong presence in the subjective experience of the personnel, influencing their work and task completions. This analytical level identifies the focused observations in the transfer phase, looking for signs of transfer from the SBT courses.

Transfer phase – Ricœur-inspired analysis

The transfer phase comprises ethnographic fieldwork in the participating departments (step 3, Figure 4).

After collecting the final data, the total dataset is watched, read, revisited and reflected upon as a *whole*. A novel naïve reading and structural analysis across all data are performed. Figure 5c reflects the units of meaning (what is said, done and observed) through transcripts from the video sequences, field notes and narratives from the field observations.

RIA reveals the participants' experiences and the researchers' understanding. The result is what appears *in front of the text*. It provides a description, understanding and possible explanations of the participant's competency development of HFS from the clinical practice phase to the transfer phase. It is, however, necessary to change the perspective to understand how this transfer of HFS happens,

Cognitive Event Analysis

CEA moves, like RIA, between the whole and the details of the video data (step 3, figure 4). Therefore, the structural analysis can be expanded through CEA, which changes the lens of the data and observes, specifically, what happens from a third-person micro-perspective. CEA begins with the emerging theme: *interruptions in planned workflow* from the RIAs structural analysis. The task is to explore if there are improvements in the participant's management of interruptions from the clinical phase to the transfer phase.

Clinical practice phase – Cognitive Event Analysis

Given the theme of interruptions in the planned workflow, innumerable cases are identified. Using CEA, scrutinise the cognitive dynamics of these cases. To exemplify a situation where an expert doctor (A) and a novice doctor (B) make a joint decision is chosen. A and B sit in an office, facing

a computer at a long desk against the wall. B makes oral noises like sighing and heavy breathing. A looks briefly at B and asks, 'Do you need help?'. B nods, and A rolls over to her looks at her screen, asks her some questions about the patient's case and moves back again. They discuss different treatment and care options and make a joint decision in a complex situation. Joint decision-making is a cognitive event; the point on the cognitive trajectory in which they reach a decision is the primary event pivot. Moving backwards from the event pivot and analysing what prompted the joint decision-making, the persons' behaviour is annotated in four area activities, gaze, vocalisation, facial expression and positioning.

Based on the annotations shown in Figure 6a$_1$, the video sequence is segmented into seven different behavioural and functional phases. Figure 6a$_2$ presents the trajectory segmentation, revealing that B interrupted A, not directly, by sighing and making noises to catch A's attention. When A becomes aware of B's sounds, A looks at B for three seconds, then rolls to B and asks, 'Do you need help?'. B nods and becomes observably less tense. Together, they look at B's screen, reflecting on the medical problems and discussing her treatment options, pros and cons. A supports her reflections by asking B for the most plausible solutions to treat the patient and helping her balance options and risks. The result is joint decision-making concerning the treatment of the patient.

In the vocabulary of CEA, the analysed situation occurs on two time scales: a problem-solving scale and an educational scale. The analysis reveals seven different HFS: situation awareness, leadership, followership, teamwork and decision-making. As novice doctors learn during work, a possible interpretation could be that they know that interruptions can lead to adverse events, that it is necessary to minimise these, and that expert doctors are very busy due to heavy workloads and teaching–learning situations. B might feel she ought to solve the clinical problem herself without support from an expert doctor busy with his tasks.

On the other hand, novice doctors are trainees and need help, support and educational guidance from competent and expert doctors to learn and avoid adverse events. This dilemma can be why it is difficult for novice doctors to ask for help and teaching. A used about 3 minutes to supervise and reflect with B to help her learn deductive and reasoning ways to move from a problem to a solution in the future. Although A could have provided B with the answer to her problem, A turned the situation into a learning event instead. Consciously or not, A and B work and train their HFS in this situation.

Simulation-based training phase – Cognitive Event Analysis

Exemplifying the CEA of the SBT phase, an acute training situation, where more qualified personnel is called to the patient room to ensure decision-making, is chosen.

The SBT scenario: A novice nurse (N1) and a nurse assistant (NA) receive an acute patient. A young woman is found outside the hospital on the pavement lying beside a bike, without a bike helmet and with scratches on her feet, arms and head. She is delirious and cannot give her full name and social security number or tell what has happened. N1 calls an expert nurse (N2) for decision support and later a doctor (D) for treatment.

Two cognitive events are identified, as shown in Figure 6b. The first is the nurses' joint decision-making, and the second is joint decision-making between N1, N2 and D.

The behaviour mapping and segmentation produce eight functional phases (Figure 6b). In phase 1, N1 and NA measure the patient's vital signs and blood gas and puts her on oxygen. N1 reflects out loud about the vital signs and blood gas results, but NA remains silent and unresponsive (lacking followership). In the second phase, N1 concludes: 'I will call (phone) N2 for help', and NA nods. N1 interrupts N2 in phase 3 when she calls her, but N2 supports N1's need for backup. In phase 4, when N2 arrives, N1 summarises the situation, repeats her reflections and presents N2 with the blood gas results. N2 reflects with N1 and concludes that the patient has a low glycaemic index and needs a doctor to prescribe the dose and volume. In phase 5, N1 calls D and interrupts her in her rounds. In phase 6, N2 send NA after the glucose fluid, almost simultaneous with N1's call to the doctor. When D arrives in phase 7, N1 resumes the situation and repeats their (N1, N2) reflections and the low glycaemic index. D takes the lead but includes N1 and N2 in joint decision-making. At the same time, NA re-enters with the glucose fluid, and N2 is ready to connect it to the patient as D prescribed it.

The analysis suggests that six different HFS come into play: situation awareness, leadership and followership, teamwork, coordination, and decision-making. Similar to the clinical phase example, two different time scales are integrated with clinical behaviour: problem-solving and educational scales. A possible interpretation could be that N1 might experience insecurity and acknowledge that she lacks competencies. She receives no support from NA, so she calls for help from a more expert co-worker. N2 is an expert and, apparently, used to guide, teach and support novices, and due to this, she does not take the lead, although N2 evidently, has experienced this situation before and knows the algorithm. N1 keeps the leadership, and N2 provides support and followership. N2 supports N1 in becoming a competent nurse to trust her competencies and decisions. In this way, the situation turns into a clinical and educational situation, where they treat the patient simultaneously as N1 learns to cope with this acute situation.

When the facilitators ask about the authenticity of the situation during the debriefing, the team recounts the everyday needs for support, teaching and learning. The team underpin that this need results in many interruptions of the expert personnel. The SBT team also concludes that these interruptions are unavoidable. Through the reflections, the team reaches the new understanding that it is okay to interrupt when one needs help, but one must do it with circumspection. The SBT team become aware of the influence of interruptions on the workflow and patient safety. Interruptions per se might be unavoidable. Still, a decrease is necessary, as some interruptions are required, but others can be avoided. Sometimes the personnel are

more focused on delivering the messages to their colleagues – getting the information out of their heads – than on the interruption problem. The team concludes that they can limit interruptions.

Transfer phase – Cognitive Event Analysis

An event where two nurses pass each other in the hallway exemplifies using CEA to study interruptions in the transfer phase.

N2 (expert nurse) walks towards the nurse station when she meets N1 (competent nurse) in the hallway. N1 looks at N1 and sends N2 a tiny smile. N2 lowers her walking speed. N1 stops, and N2 joins. N1 initiates the talk; she needs help. They both outline their planned tasks and coordinate these. In this situation, three events are identified: (1) an unplanned coordination and decision-making, (2) a sudden unintended joint care for a moaning patient, and (3) a joint decision to change plans again.

As shown in Figure 6c, a moaning patient catches their attention and interrupts their coordination. With brief eye contact, they change their plan and enter the patient's room. Back on track, they meet the husband, whom the nurses know cannot speak with his demented wife, so they inform him of the current situation.

The mapping and analysis of the event (Figure 6c) result in nine different behavioural and functional phases where four different HFS come into play: situation awareness, teamwork, coordination and decision-making. In phase 1, N1 stops N2 with eye contact and a smile; she needs help. In phase 2, the nurses plan and coordinate their tasks when they hear a moaning patient nearby. In phase 3, N1 and N2 look briefly at each other, turn around and enter the room to care for the patient. Later, in phase 5, the patient's husband arrives on their way to the planned joint task. The husband looks at N2 and smiles. In phase 7, N2 gazes briefly at N1, then back at the husband, stops and informs him. N1 waits silently at N2's side. The nurses are once more interrupted in their plans. They prioritise informing the relative before they continue with the planned tasks. This decision is hypothetically reached through eye contact and smiles.

A possible interpretation is that the meeting in the hallway allows N1 to ask for help with a tiny smile. N2's action of slowing down her speed could be her reaction to N1's smile and nod and signal to N1, *You can interrupt me*. In the same way, they communicate silently and with their eyes and smile when they choose to take care of a moaning patient and, later, her husband. The nurses demonstrate a kind of interruption readiness. Based on the nurse's knowledge of the patient, they prioritise caring for her before their planned tasks. They do not decide with words, but with a glance at each other. It is plausible to say that the nurses use their HFS and tacit knowledge both when interrupted and when they make quick decisions and change their plans from the original due to new unplanned situations. Although they had other plans, they changed them due to the needs of the present situation.

RI-CEA critical interpretation and discussion

The final step of RI-CEA is a critical interpretation and discussion of the results from the analytical processes (step 3, Figure 4). The parts (units of significance and themes from RIA and CEA analysis) are gathered and critically interpreted. In the critical interpretation and discussion, the researcher intends to achieve a more profound, enlarged and sophisticated understanding of results, their validity and generalizability. The new understanding illustrates the data acquisition and facilitates the movement of the findings from an individual level to a universal level by discussing the results with other relevant theories and studies [3,26]. In discussing the results, the overall results are reviewed and then validated by asking if these results are plausible in light of the whole SimLEARN dataset and research question regarding transfer of learning. Is it conceivable that SBT of HFS can develop the personnel's awareness of interruptions and begin changing their articulation and behavioural actions in everyday practice? And if yes, how did this transfer happen? This validation is then discussed by including relevant literature about the effectiveness of SBT, re-learning, development of new skills, and transfer of learning. Secondly, the generalizability of the results is appraised by considering if the results can be universal or not.

Two themes emerged from the analytical process: interruption readiness and clinical education. In some ways, these themes are intertwined in daily practice. The Danish hospitals' constant flow of newly educated personnel, as well as a high personnel turnover, creates a need for continuous learning; the expert personnel must support, guide, teach and educate the novices to cope in a complex shifting practice with high emotional demands. In addition to pursuing tasks, the expert personnel must develop an interruption readiness to cope with the inevitable interruptions from younger colleagues. One can wonder why this interruption readiness skill is not a focus when introducing or training newly educated healthcare personnel. The results show how the healthcare personnel, through SBT, become aware of the importance of HFS competencies to cope with interruptions in their everyday clinical practice [45]. Data indicate a change in the personnel's awareness, talk and considerations about interruptions.

The outcome of the HFS training is learning on an individual level and not changing the local organisation's way of working with interruptions. This might be due to the researchers' lack of emphasis and unclear feedback to the department managers regarding the need for subsequent implementation of the SBT outcome, continual focus on interruptions and the importance of the interruptions for the novices learning, the experts' workflow and patient safety. Comparing possible changes through SimLEARNS' three phases (clinical, SBT and transfer), it is conceivable that the SBT focusing on interruptions can have changed and articulated some participants' behaviour around interruptions.

Figure 5: (A) The analytic process from naïve reading to the structural analysis of the clinical phase. (B) The analytical process from naïve reading to the structural analysis of the SBT phase. (C) The naïve reading and the structural analysis of the overall data. A shows the analytical process in the clinical phase, B in the SBT phase

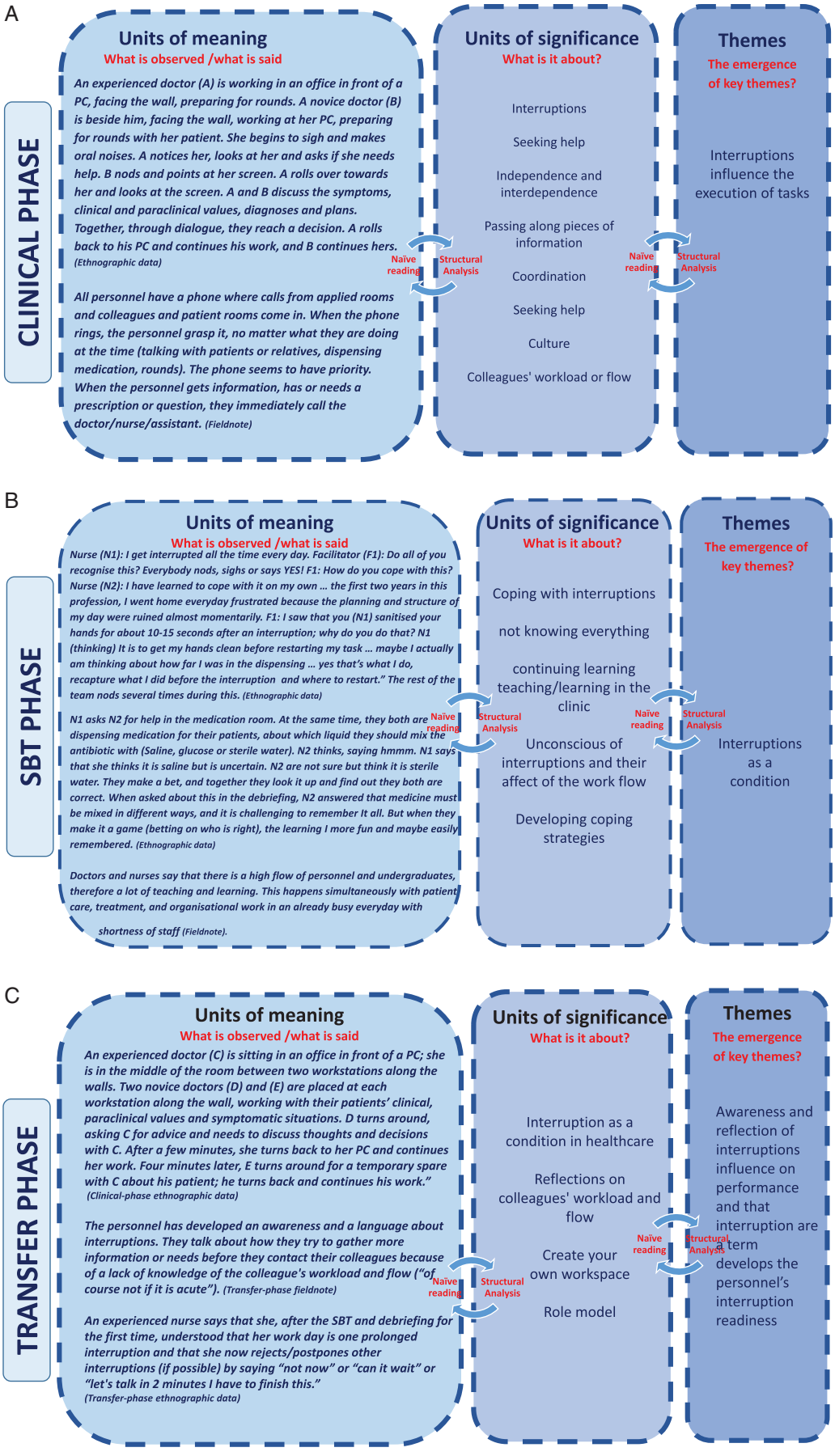
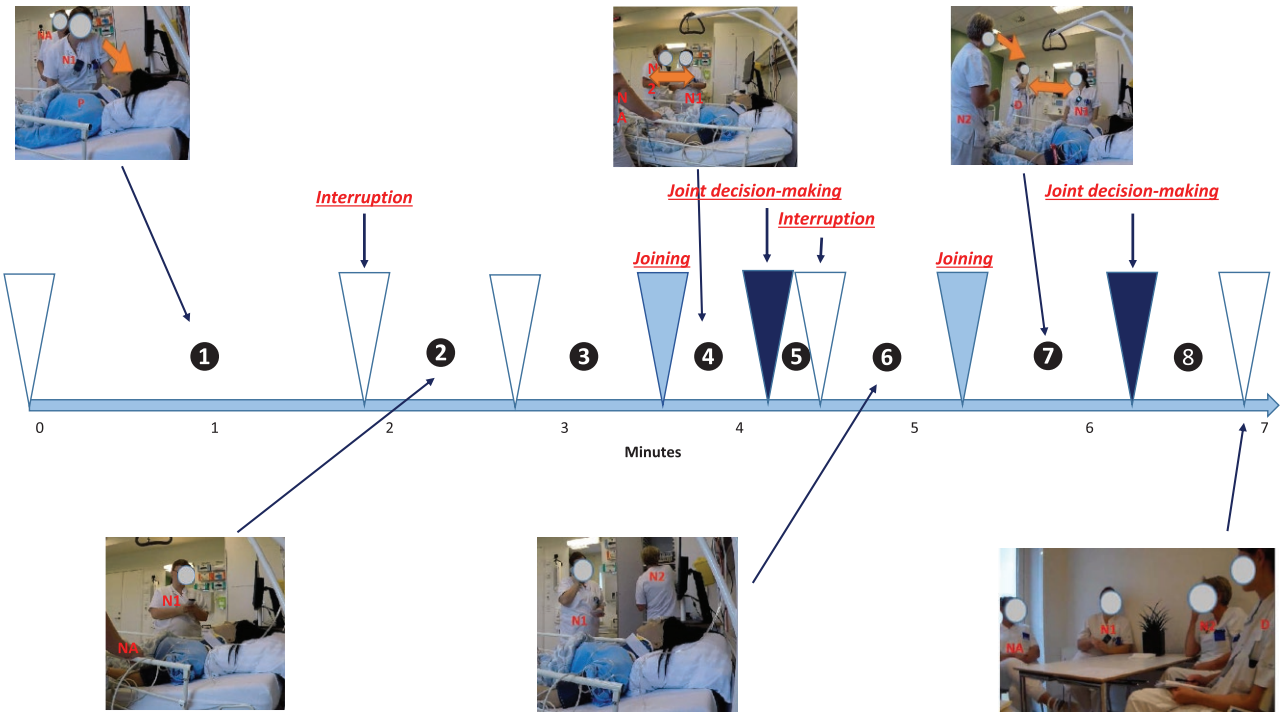


Figure 6: Note to Artwork: Missing figure 6a1 and 6a2. There should be 3 parts of CEA analysis, right now there are 2 parts. The annotation figure are only present for the first CEA analysis, that means that 6a1 are different from the other figures in figure 6. Sorry I know its big data. (a_1) Data annotation of activities, phases and behaviour. (a_2) Cognitive Event Analysis with microlens interpretation of interruptions. (B) Cognitive Event Analysis of interruption in the simulation-based training phase. (C) Cognitive Event Analysis of interruption in the transfer phase

B

CEA step	Results
1) Cognitive event identification	Two different events are identified. First, N1 and N2 make a joint decision. Second, N1, N2 and D make a joint decision.
2) Event pivot identification	Secondary event pivot: N1 interrupts N2 by phone, N1 is novice and needs support. N1 tries to get this from NA who does not reply, N1 calls N2. N2 is in the middle of another task but will arrive ASAP. Primary event pivot: N1 interrupts D in her rounds, calls her to the room to prescribe medication.
3) Data annotation	Examining shifts in NA, N1, N2 and Ds behaviour (gaze, vocalisation and positioning) (Figure $_{7b_1}$)
4) Cognitive trajectory segmentation	Mapping the event structure and the behavioural phase by splitting the situation up. Eight different phases are found in this situation (❶-❽)
5) Cognitive trajectory analysis	Six different human factor skills come into play in this situation: Situation awareness, leadership and followership, teamwork, coordination and decision-making.



Discussion of RI-CEAs applicability of confirming transfer

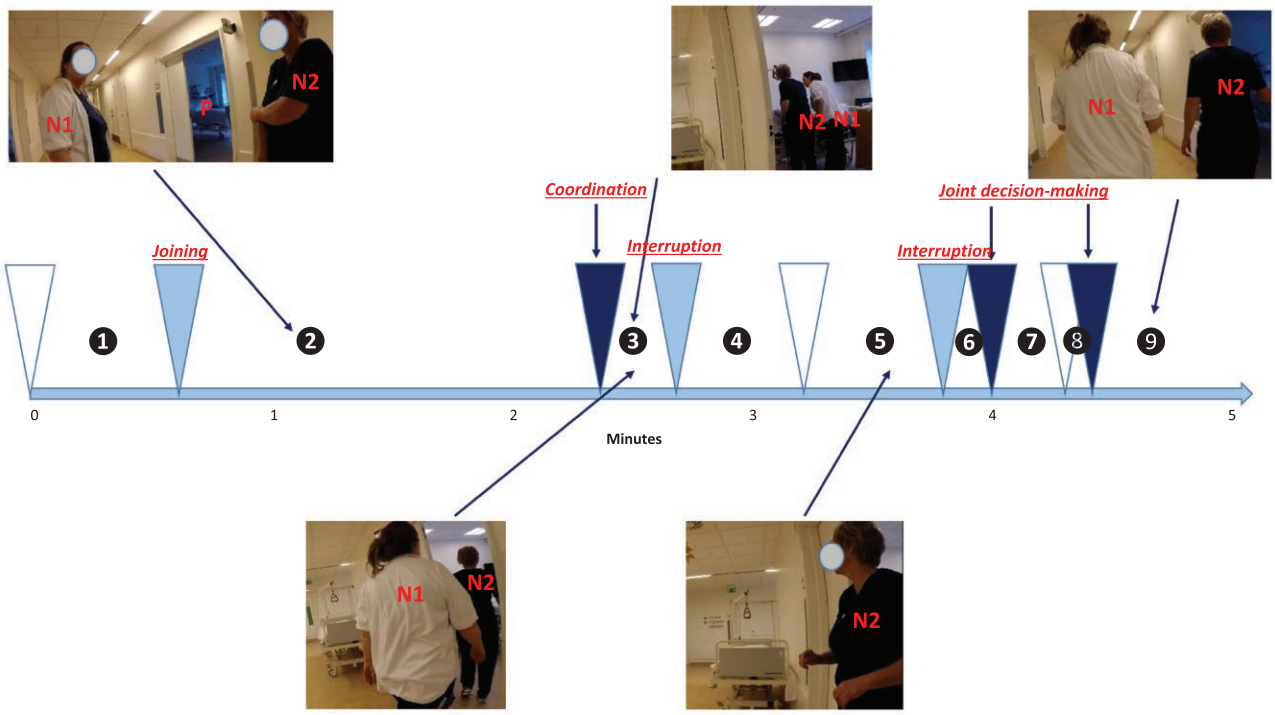
The research question's transfer perspective requires more than understanding and explaining how humans develop competency through educational interventions. RIA offers insight into the personnel's *being in the world.* CEA provides a change of lens on data from what emerges in front of the text (RIA) to an analysis of the personnel's cognitive changes (CEA) during and after the intervention.

Expanding RIA with CEA in a phenomenological–hermeneutic frame gives a broader picture of how healthcare personnel transfer HFS from SBT to competency in the everyday are gained. RIA investigates the understanding and explanation, whereas CEA investigates the *how* based on real-time dynamics and non-local conditions. The structural analysis clarifies that RIA cannot answer how transfer happens independently. A need to understand not only if transfer happens but also how transfer occurs; the CEA add-on is necessary to gain insight into the how. The SimLEARN case shows that integrating CEA in RIA's structural analysis broadens the analytical outcome and expands the research outcomes to a strengthened result. The CEA microlens perspective on the cognitive and real-time activities enhances the validation step of RIA.

The two methods complement each other and expand the analytical result of the ethnographic data. Both methods progress in movements between parts and whole, and between understanding and explanation, and in that way, complement

C

CEA step	Results
1) Cognitive event identification	Three different events are identified. First, N1 & N2 make joint coordination of tasks. Second, N1 & N2 make a joint decision to change plans. Third, N1 & N2 make a joint decision to change plans again.
2) Event pivot identification	Primary event pivot: N1 and N2 walk (unexpectedly) towards each other in the hallway. When they look at each other, N1 smiles and makes a tiny nod to N2, and they stop up and coordinate collaborative care tasks. Secondary event pivot: A disabled woman with dementia moans more frequently and loudly in a nearby patient room. N1 and N2 look each other in the eyes, walk to the patient's room and check her and the environment for potential problems. Tertiary event pivot: Leaving the patient they met the husband. N1 informs the husband of the patient's current condition.
3) Data annotation	Examining shifts in N1 and N2s behaviour (gaze, vocalisation and positioning) (Figure $7c_1$)
4) Cognitive trajectory segmentation	Mapping the event structure and the behavioural phase by splitting the situation up. Eight different phases are found in this situation (❶-❽)
5) Cognitive trajectory analysis	Four different human factor skills come into play in this situation: Situation awareness, coordination, teamwork and decision-making



each other. CEA works with the processes that occur in the interbody dynamics, whereas RIA offers the personnel's understanding and transformations across the three phases. This can show how cognitive processes present themselves in normative, structural and synchronic interbodily dynamics, which more traditional approaches in healthcare sciences cannot reach. The RI-CEA method is time consuming – more than 100 hours of video, field notes and self-reflection. Therefore, RI-CEA might not be the preferred method to confirm transfer. However, it can broaden the insight into the phenomena of transfer and be the foundation to develop a more useable and accessible approach to grasp transfer of HFS.

The theoretical and practical combination of analysing the data *opened* up the data to *what was going on*, *what it was about*, *how did the personnel function and behave* and *did it change practice*. The lived experiences of the qualified personnel during and after an SBT course reveal and confirm if HFS is transferred to everyday clinical practice. This lens shift adds an in-depth picture of the personnel's behaviour and possible behavioural changes in HFS skills after SBT. For instance, where a competent and an expert nurse meet. N1 gazes and smiles at N2, and N2 reduces her speed. This could indicate N1's new competency in reading N2's interruption readiness. When N2 reduces her walking speed, N1 initiates a talk and expresses her need. Expanding RIA with a CEA, a hybrid method has been designed, containing approaches which might give insight, understanding and explanation of transfer.

Conclusion

The hybrid method with RIA and CEA can capture transfer. The hybrid method expands the existing insight into how

and if transferring human factor skills after simulation-based training becomes competency. By observing the data closely, the personnel's performance becomes visible, and it is possible to train towards a desirable goal (e.g. manage interruptions) and, through in-depth analysis, perceive how the personnel gains a new language around interruptions, and for some personnel changed behaviour. However, this hybrid method is time consuming and needs further development and evaluation.

Limitations

A few limitations of this description of the hybrid method must be highlighted. Firstly, the hybrid method is experimental in an ongoing project, and the final results still need to be done. The researchers tried to meet this challenge by unifying experts in both project methods (healthcare science and social science). This allowed the researchers to reflect on and discuss this hybrid method's pros, cons and extent. Secondly, the department leaders pointed out the participants, which could influence the psychological safety issue. However, all participants were allowed to decline participation. The course was not mandatory, and therefore, is a positively biased result possible because the participants had accepted SBT as a learning method [46] and possibly wanted the study to succeed. The researchers tried minimising this limitation by selecting the participants on the day within the group of staff on duty. Finally, there is a risk of observer bias, a systematic variation in the observations [46], which can reduce the hybrid method's applicability. This could have contributed to concluding transfer where there was none, but instead a coincidence. Nevertheless, video analysis makes it possible to revisit the situations, behaviour and responses from the participants and field notes multiple times, reflect and discuss these in the researcher group to validate the findings.

Declarations

Authors' contributions

Lotte Abildgren drafted the article. All authors critically revised the manuscript and the authors read and approved the final manuscript.

Funding

Anesthesiology and Intensive Care Department V, Odense University Hospital, Denmark, Department of Clinical Research, University of Southern Denmark & Hospital Sønderjylland, Aabenraa, Denmark.

Availability of data and materials

None declared.

Ethics approval and consent to participate

None declared.

Competing interests

None declared.

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Notes

[1] Human factor skills: human factors include social skills, cognitive skills, decision-making skills and puts emphasis on how the environment, the organisation and human psychology interact.

[2] Competency: defined as a skill developed on basis of knowledge, experiences and behaviour towards qualified activities that can be put into action in everyday practice. Competency demands actions, which are both intentional and directed, as well as individual, personal and subjective. This definition is inspired by the Danish pedagogic term action competencies.

Paper III

From Training to Competency– Findings from a qualitative investigation of transferring health personnel's human factor skills

by Lotte Abildgren[1-6], Malte Lebahn-Hadidi[7], Christian Backer Mogensen[3], Palle Toft[1,6], Sune Vork Steffensen[4,5,8-10], Lise Hounsgaard[2,11]

[1]*Anesthesiology and Intensive Care Department, Odense University Hospital, Odense, Denmark*
[2]*OPEN, Open Patient data Explorative Network, Odense University Hospital/Department of Clinical Research, University of Southern Denmark, Odense, Denmark*
[3]*Emergency Research Department, Hospital Sønderjylland, University Hospital of Southern Denmark, Odense, Denmark*
[4]*CFPK, Centre for Research in Patient Communication, Odense University Hospital, Odense, Denmark*
[5]*Centre for Human Interactivity, Department of Language and Communication, University of Southern Denmark, Odense, Denmark*
[6]*Department of Clinical Research, University of Southern Denmark, Odense, Denmark*
[7]*Centre for Shared Decision Making, Lillebælt Hospital, Denmark*
[8]*Danish Institute for Advanced Study, University of Southern Denmark, Odense, Denmark*
[9] *Center for Ecolinguistics, South China Agricultural University, Guangzhou, China*
[10]*College of International Studies, Southwest University, Chongqing, China*
[11]*Institute of Nursing & Health Science, Ilisimartusarfik, University of Greenland*

Source(s) of funding support:

- Anesthesiology and Intensive Care Department, Odense University Hospital, Denmark
- Center for Patient Communication & Human Skills, Clinical Development, Odense University Hospital, Denmark
- Centre for Human Interactivity, Department of Language and Communication, University of Southern Denmark, Odense, Denmark
- Department of Clinical Research, University of Southern Denmark
- Hospital Sønderjylland, Aabenraa, Denmark

List of abbreviations

ANTS:	Anaesthetists' Non-Technical Skills
CEA:	Cognitive Event Analysis
HFS:	human factor skills
RIA:	Ricœur Inspired Analytical approach
RI-CEA:	Hybrid method of a Ricœur Inspired Analytical approach and Cognitive Event Analysis
SBT:	Simulation-based training

Abstract

Background: Research shows that simulation training can increase knowledge and skills among pregraduate healthcare students, that simulation training of technical skills places the participants higher on the learning curve in practice, and that simulation training can improve participants' human factor skills. However, how simulation training is transferred into clinical practice competency is unknown. This study aims to explore qualified in-hospital health personnel's transfer of human factor skills from a simulation training course to competency in everyday clinical practice.

Method: An ethnographic study investigates qualified health personnel's transfer of human factor skills before, during, and after a simulation training course. Data collection comprises three phases: a clinical phase, a simulation training phase and a transfer phase; each phase is based on a subsequent analysis of the previous phase. Data consist of approximately 107 hours of video recordings, field notes and reflections from the research team. Data are analysed with a qualitative hybrid method of a Ricœur-Inspired Analysis and Cognitive Event Analysis.

Findings: The analysis reveals three key themes: *Individual transfer of learning*, *Intercollegiate transfer of learning* and *Organisational transfer of learning*. The findings imply that transfer of human factor skills happens on an individual and intercollegiate level, but transfer needs to be scaffolded on an organisational level, for which reason knowledge does not become competency in clinical practice. Transfer, internalisation and retention of human factor skills are inadequate because of insufficient organisational focus on transferring human factor skills.

Trial registration: N/A

Keywords MeSH

Crew Resource Management, Healthcare; Health Personnel; Human Factor Skills; Patient Simulation; Safety Management; Simulation Training; Transfer, Psychology.

What this study adds

- Transferring human factor skills demands a triple focus on individual, intercollegiate and organisational learning in the transfer phase to engender competency among health personnel.
- Transferring newly trained human factor skills from simulation training to competency in clinical practice needs organisational effort and support to succeed.
- Transferring human factor skills demands awareness and a mutual way of talking about human factor skills among health personnel and management.
- Technical skills training focuses on individual learning, but human factor skills depend on individual learning, intercollegiate learning and organisational learning, and so must the transfer process.
- Transfer of human factor skills demands an increased collaboration between the simulation-based education faculty and the management in clinical practice.

Background

This article presents the findings of a study into health personnel's (HP) transfer of human factor skills[1] (HFS) (1) from simulation training (SBT) to competency[2] (2) in complex clinical practice. Human factor skills are frequently named non-technical skills, crisis resource management, or interpersonal relations; however, these concepts have limitations as they narrowly define competence in terms of deficiencies (non-technical skills), specific purposes (crisis resource management), or interpersonal dynamics (interpersonal relations) (6, 10-14). A more encompassing framework is found in human factors, e.g. as presented in the SHELL model, which considers a broader spectrum of human interaction, incorporating social skills, cognitive abilities, and decision-making. Moreover, it emphasises the interplay between the environment, organisation, and human psychology (15). In light of this perspective, this article implements the term *human factors skills* (HFS) to denote the skills under examination.

SBT can increase knowledge and skills among pregraduate healthcare students (3, 4). SBT of technical skills places the participants higher on the learning curve when performing in clinical practice (5, 6), and participants can improve their HFS through SBT (7, 8). Further, appropriate HFS reduce adverse events (9, 10). To link these results, the condition for transferring HFS knowledge into competency in clinical practice needs to be identified.

Skills transfer is a social process involving more than cognitive processes (11). Moreover, HFS is embedded in one's personality and cultural background (12). Transfer is defined as the application of learning from SBT into clinical competency in the participants' everyday; that is, what personnel learn in one setting can be used in another comparable but different setting (13, 14). This study is part of the SimLEARN project (Figure 1) that integrates a social science perspective (15) and a health science perspective on transfer of HFS with shared data.

The relevance of researching skills transfer relates to the vast problem of patient safety (16, 17), lack of HP, a high personnel turnover and the well-being of personnel (18, 19). To reduce the number of adverse events in healthcare, SBT is increasingly used to teach, train and maintain the knowledge and skills of qualified in-hospital HP worldwide (20-22).

Given the gap in the research literature, developing new knowledge about how HFS knowledge becomes competency in clinical practice is crucial. The present study, therefore, investigates how transfer becomes competency in clinical practice after SBT.

Aim

The aim was to develop an understanding of how qualified HP transfers human factor skills from an in situ Simulation training course to competency in complex everyday clinical practices.

[1] Human Factor skills: include social skills, cognitive skills, decision-making skills and puts emphasis on how the environment, the organisation and human psychology interact (1).

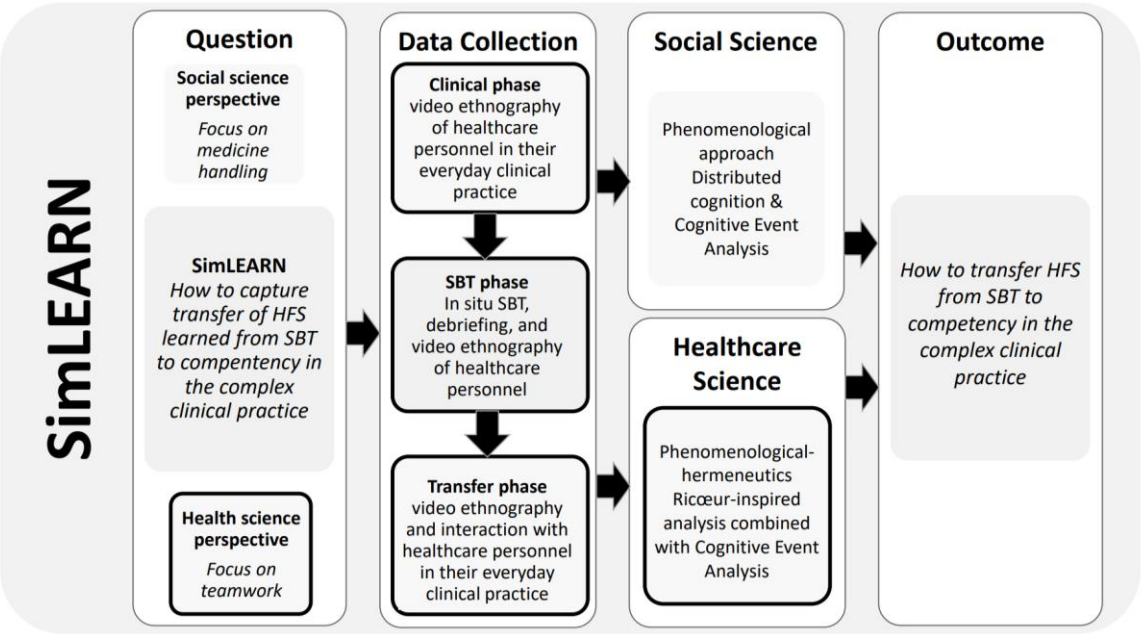
[2] Competency is defined as a skill developed on basis of knowledge, experiences and behaviour towards qualified activities that can be put into action in everyday practice. Competency demands actions, which are both intentional and directed, as well as individual, personal and subjective. This definition is inspired by the Danish pedagogic term "action competencies" (2).

Methods

Study design

A qualitative phenomenological-hermeneutic methodology and ethnographic data were used to investigate the transfer of qualified HP's HFS before, during, and after an in situ SBT course. The findings of the health science part of SimLEARN, illustrated in Figure 1 and marked with a purple contour, are presented in this article.

Figure 1: The SimLEARN Study Design



Settings

The data was collected in four different wards at two Danish hospitals - a university hospital (965 beds, ~11,000 personnel) and a local hospital (302 beds, ~2,600 personnel). The included wards are two ICUs (54 beds, 8 beds), an emergency ward (42 beds) and an infectious disease ward (15 beds).

Participants

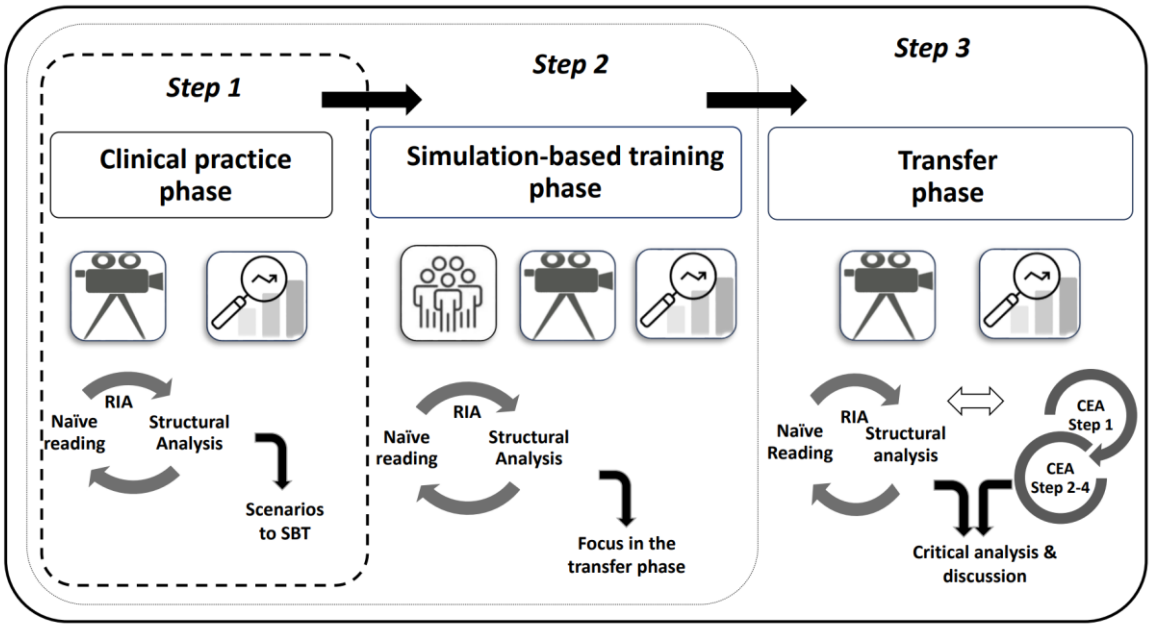
The participants were at-work clinical HP (doctors, nurses, physiotherapists, radiologists, nurse assistants, medical students, nursing students, technicians and secretaries). The participants were selected from the duty schedules on the days of data collection and SBT course to match a realistic everyday team. Thus, the competency on the day was similar to the expected span from beginner to specialist (five stages of expertise: novice, advanced, competent, proficient and expert) (23, 24). However, all personnel could opt to decline participation. Participants gave informed consent.

Ethnography

Inspired by Spradley (25) and Pedersen & Humle (26), two of the authors (LA & MLH) collect ethnographic data in three phases by shadowing HP with video cameras, observing their work, talking formally and informally in their everyday clinical practice. The observations of HFS were based on the ANTS framework (27, 28). Figure 2 shows the study design's three phases of data collection: Step 1 - *Clinical practice phase*:

ethnographic data collection of HP's HFS in clinical practice. Step 2 – *SBT phase*: ethnographic data collection during an in situ SBT course. After steps 1 and 2, an initial analysis led to the focus in the following ethnographic step. Step 3 - *Transfer phase*: Ethnographic data collection of HP using HFS in everyday clinical practice after participating in SBT.

Figure 2: Data collection and assessment of data



In situ Simulation training

Intervention: As illustrated in Figure 3, the intervention comprised preparatory information meetings (~1 month before data collection begins), a screencast about HFS mailed to all personnel (~1 week before SBT) and two days of SBT in each participating ward.

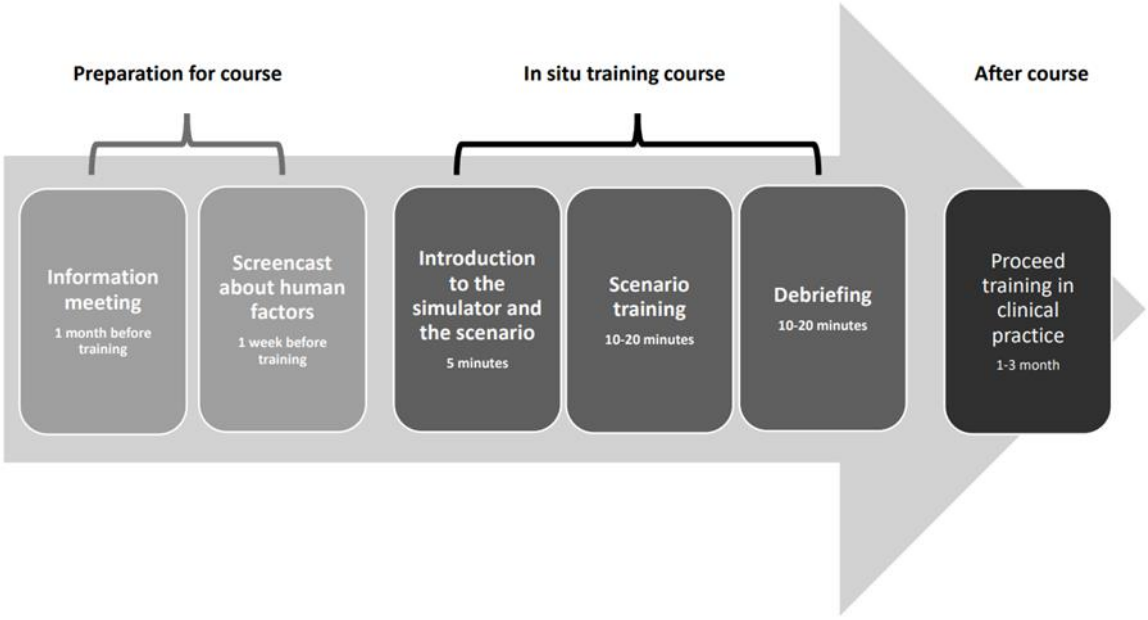
The first author (LA) developed the training scenarios based on the initial analysis of the clinical phase, from which HFS learning objectives were chosen. The scenarios were tested and validated by simulation operators and external facilitators. The facilitators had a facilitator course (~EuSim level 1 and 2) and 2-10 years of experience as facilitators. The study objectives and methods were presented in a pre-training meeting with the facilitators. Further, the facilitators were aligned to the debriefing process, focusing on HFS, reflecting on the trained cases and making analogies to similar situations in the clinical practice.

Simulator: The patient simulator used in the training course was Laerdal Medicals Nursing Anne Simulator (model 2019).

In situ training: Each SBT day consisted of three high-fidelity training sessions, including a 5-minute introduction to the simulator and the simulation situation, 10-20 minutes of in situ training, and a 25-30-minute debriefing (29-32) led by the facilitators (1 doctor, 1 nurse). Four to six personnel participated in each scenario. The clinicians could participate in one to three of the scenarios. Two researchers (LA, MLH) observed, and three cameras recorded the training and debriefing from different positions.

Transfer: After the two days of in situ simulation, the wards' participants and heads (the daily leaders in the ward) were responsible for continued training and internalising the newly trained HFS. The heads were provided with a comprehensive list of the recently gained skills, attention points, and suggestions for further training after the SBT course.

Figure 3: Illustration of the intervention flow



Analysis

The complexity of investigating changes in human behaviour called for a qualitative method comprising at least 1) a theoretical framework integrating social, psychological and cognitive aspects of performance, 2) an investigation of how HFS is taught, trained, learned and transferred, and 3) approaches to describe, understand and explain how HFS transfers into clinical competency. Therefore, a hybrid of two methods was designed: a Ricœur Inspired Analytical approach (RIA) (Figure 4) and Cognitive Event Analysis (CEA) (Figure 5). The hybrid method is called RI-CEA (33). Data were initially analysed with RIA immediately after the clinical and SBT phases to incorporate the findings and focus on the following phase. After the transfer phase, all data were analysed with RI-CEA as one complete dataset. The CEA analysis was incorporated in the RIAs' structural analysis, as demonstrated in Figure 2, step 3.

Findings

Data were collected between February 2019 and February 2020. Data consisted of video recordings, field notes and reflections between the two researchers (LA, MLH). The data collection resulted in approximately 107 hours of ethnography of HP's teamwork.

Within three months, the clinical phase was completed. Two days of ethnographic fieldwork were achieved in each participating ward (8 days total, 17 personnel), equalling ~47 hours of video data and field notes. The subsequent analysis led to six themes: *coordination, interruptions, educational responsibilities, teamwork, and situational awareness,* integrated into the SBT training course.

Figure 4: The Ricœur Inspired Analytical approach (RIA)

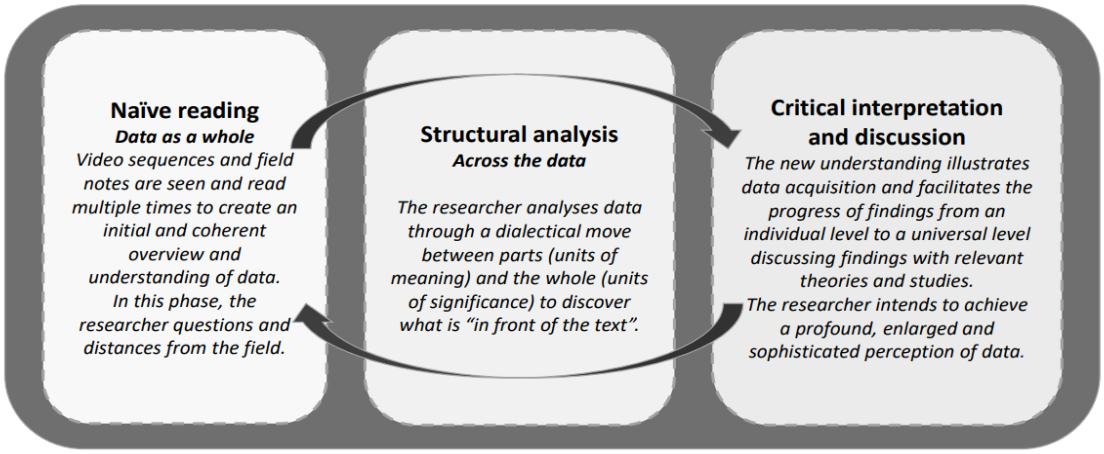
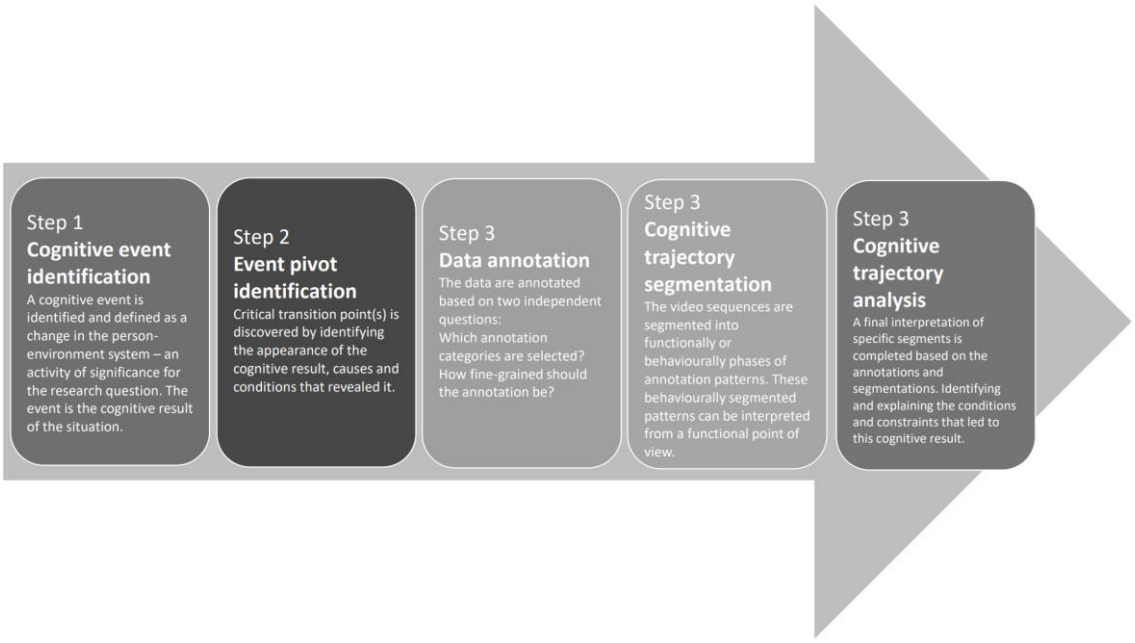


Figure 5: The Cognitive Event Analysis (CEA)



Seven days of in situ training (21 scenarios and debriefings) were held (~52.5 hours of video data) within two months. Four expert facilitators (two doctors and two nurses) completed all the debriefings. 45 HP participated in the SBT course. Due to a lack of personnel and resources to participate, only one training day was completed in the infectious disease ward.

The SBT phase was completed within three months. The findings from RIA showed the immediate learning and training outcomes and, thus, nine themes: *psychological safety, educational responsibilities, professional back-and-forth, teaching and learning during work, feedback from colleagues and HFS, leadership, teamwork, situation awareness, decision-making and task management.*

The transfer phase was cut short due to the COVID-19 pandemic. Only two days (4 nurses) of ethnographic fieldwork (7.5 hours of video data) were completed at the local hospital, in the ICU and emergency department. After data were gathered, the RI-CEA analysis of the complete data set began. As illustrated in Figure 6, RIA moved dialectically between parts and wholes, between observations and statements. CEA explored real-time behaviour dynamics and took third-person macro-to-micro

perspectives of the units of significance by identifying the cognitive result (i.e. joint decision-making) and working backwards to understand what caused the outcome, as illustrated in Figure 7. Finally, an integrated critical analysis of the findings was completed, resulting in three key themes, which are expanded below.

Figure 6: An example of the systematic process of structural analysis in the Ricœur Inspired Analytical Approach (RIA)

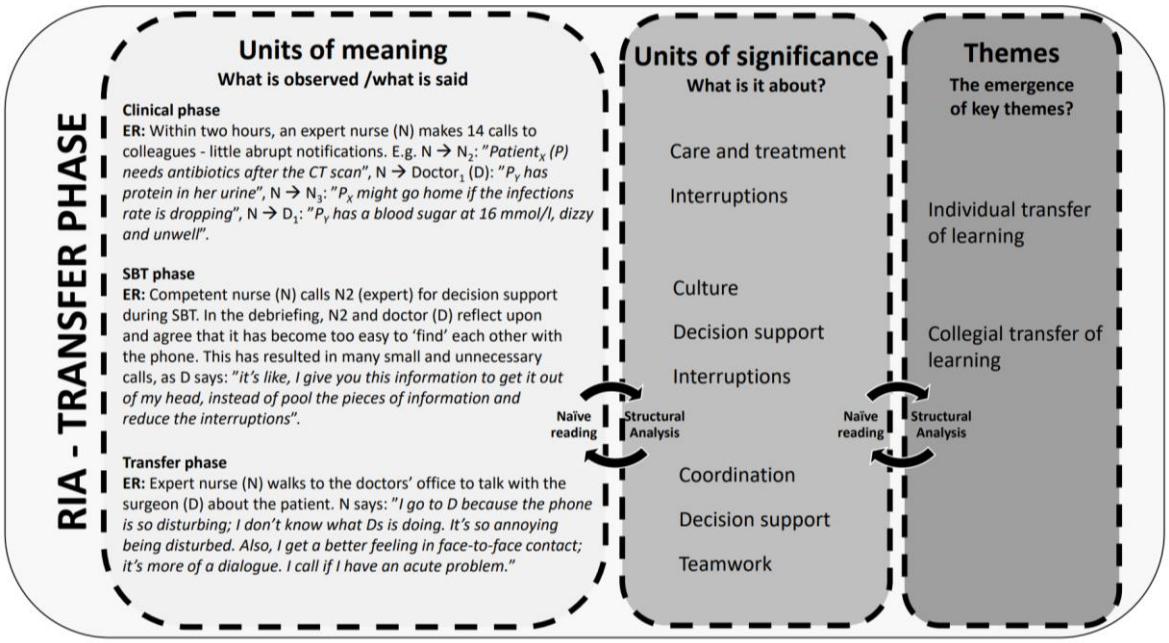


Figure 7: An example of the systematic process of Cognitive Event Analysis (CEA)

The five CEA steps and their content. Step 3 is expanded below the five-step overview. Based on the annotations shown in the video sequence is segmented into seven different behavioural and functional phases.

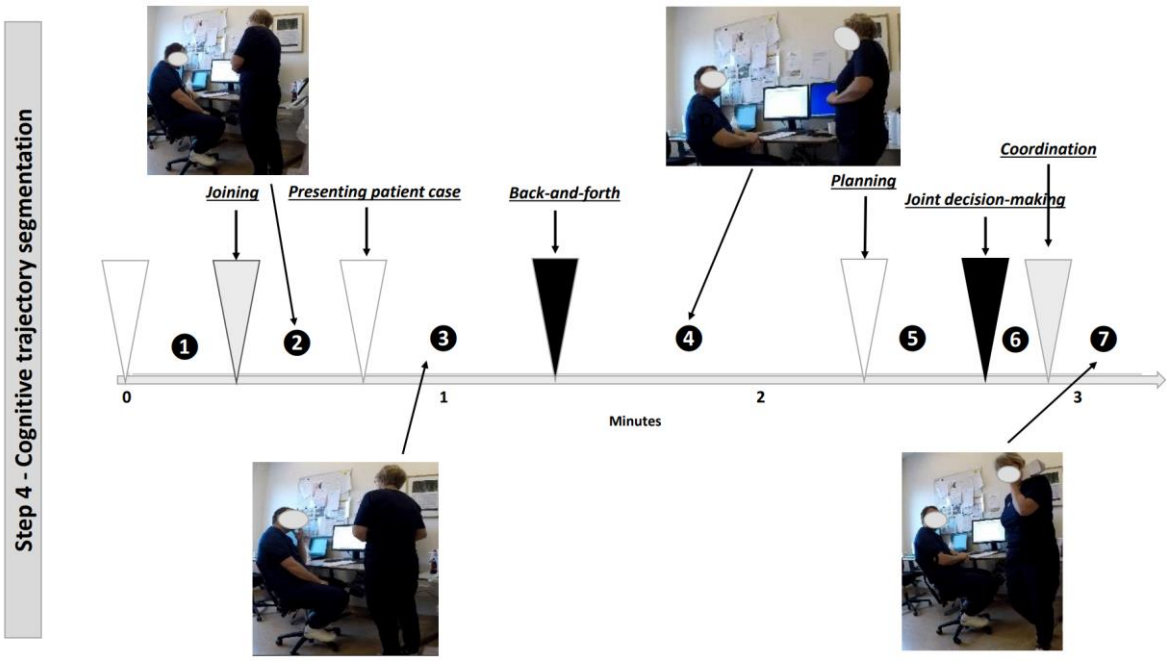
CEA steps	Results
1) Cognitive event identification	Two different cognitive events are identified First, D and N makes a joint decision Second, D and N has a peer-to-peer back-and-forth
2) Event pivot identification	Secondary event pivot: N enter the doctors' office, N need to discuss P's case, and coordinate the care plan Primary event pivot: Based on the discussion of the situation D and N make a plan and a treatment strategy
3) Data annotation	Examining shifts in D and N's behaviour (gaze, vocalisation and positioning)
4) Cognitive trajectory segmentation	Mapping the event structure and the behavioural phase by splitting the situation up. Seven different phases are found in this situation, from the nurse entering the room until she leaves after their joint decision-making and coordination (❶-❼)
5) Cognitive trajectory analysis	Three different human factor skills come into play in this situation: Situation awareness, teamwork and decision-making.

Step 3 – Data annotation

Subject	Behaviour	❶ Arrive	❷ Joining	❸ Case	❹ Back-and-forth	❺ Care plan	❻ Decision-making	❼ Coordination
N1	Gaze	D	D's paper	D	Room	D	D	Door
	Vocalisation	÷ vocal	+ vocal	+ vocal	+ $vocal_{back\text{-}and\text{-}forth}$	+ vocal	+ $vocal_{decision\ making}$	+ vocal
	Positioning	Stand $Front_D$	Stand $Front_D$	Stand $Front_D$	Stand $Front_D$	Stand $Front_D$	Turn $away_D$	$Back_D$
	Facial expression	Smile	Neutral	Neutral	Openness	Openness	$Nodding_{listening}$	Neutral
D1	Gaze	Screen	Paper	N	N	N	N	Screen
	Vocalisation	÷ vocal	÷ vocal	+ $vocal_{ask}$	+ $vocal_{back\text{-}and\text{-}forth}$	+ vocal	+ $vocal_{Decision\ making}$	+ vocal
	Positioning	Sit Screen	Sit $Front_N$	Sit $Front_N$	Sit $Front_N$	Sit $Front_N$	Sit $Front_N$	Sit $Front_{Screen}$
	Facial expression	Neutral	Smile	Aware	Openness	Openness	Neutral	Smile

Step 4, the trajectory segmentation, revealing that N interrupts B, not directly; N is standing smiling but silently in the doorway, waiting for D to notice her. When D becomes aware of N's presence, D looks at N. N, and D joins at D's desk. N presents the patient's case; both look at D's paper on the desk. D asks additional questions. D and N have a professional back-and-forth about different solutions and treatments. Hereafter they plan the next step and make joint decision-making. D says, "If you do that, I will do this, and then we

speak with the patient and her husband together?". N replies, "Yes, we agree; see you in 10 minutes". D nods and smiles. N turned around to leave the room, and D continued his previous task.



Themes and subthemes

Through RI-CEA's systematic analysis, three key themes emerged: 1) Individual transfer of learning, 2) Intercollegiate transfer, and 3) Organisational transfer of learning. Each key theme has subthemes. The themes are intertwined and mutually dependent but have different perspectives and content. The themes and subthemes that emerged through RI-CEA, as shown in Figure 8, will be elaborated on in the following.

Figure 8: The themes and subthemes that emerged through the Ricœur Inspired and Cognitive Event Analyses (RI-CEA)

Themes	Subthemes
Individual transfer of learning	• Knowledge and awareness of HFS • Reflection of one's behaviour and actions • Triple awareness in learning and working
Intercollegiate transfer of learning	• Speaking HFS • Psychological safety • Develop HFS together
Organisational transfer of learning	• Awareness of HFS's impact on patient care • Equality between HFS and Technical skills • Psychological safety and support

1. Individual transfer of learning: The characteristics of this theme were that the individual HP had an immersed role and obligation in integrating new HFS as a competency in everyday clinical practice. They experienced personal responsibility for integrating new knowledge from the SBT course into their everyday clinical practice. A nurse said: "*It [transfer] is not something we talk about or address after a course; it's solely my responsibility*."

This theme had three subthemes: a) Knowledge and understanding of HFS, b) Reflection on one's behaviour and actions, and c) Triple awareness in learning, teaching and working.

1a. Knowledge and awareness of HFS. The knowledge and awareness of HFS before the SBT course were mostly limited to the concept of, e.g. ANTS (Anaesthetists' Non-Technical Skill) (28, 34) and the importance of HFS in acute situations. Several participants highlighted in the debriefings and informal talks that HFS was not a topic or a focus in the clinical practice: "*… only if it's a critical situation."* Clinical practice focused primarily on technical skills and implementation of algorithms, new medical procedures, and using a new utensil or tool. In a debriefing, an expert nurse said: "*It's interesting to reflect on our interruption culture [situation-awareness]. Only now, I understand that HFS are more than closed loops and ABCDE and that it also influences our everyday work*." In the transfer phase, the same nurse said: "*After the SBT course, I realised that my workday is one long interruption. I have tried to change my habits of interrupting others. However, I end up doing as usual [routine]*." These two quotations showed that this nurse had become aware of HFS, gained knowledge about HFS and its impact on her work, and tried to transfer the awareness into her complex clinical everyday.

1b. Reflection of one's behaviour and actions. Most participants declared that the SBT course offered a platform for reflecting upon their behaviour and actions. After a debriefing, a competent doctor said, "*The focus solely on HFS in the talks [debriefing] made me look inward on my behaviour. I couldn't hide behind my medical knowledge; I had to check my side of the interactions. Now I understand and am trying to become a better team player*." In the transfer phase, the reflection of one's actions was observed when a competent nurse thought out loud in her teamwork with another nurse when preparing to transfer her patient from the ICU: "*… if I do this first, then we have more room for that [informing the patient] later*." The findings indicated that the HFS focus on reflection about one's behaviour and actions could lead to an insight into one's role in the interaction and that HP needs more than medical knowledge.

1c. Triple awareness in teaching, learning and working. A triple awareness - balancing learning, teaching and working - was observed across all three phases. Learning, teaching and working are not HFS; however, the skills of balancing between learning, teaching and taking care of the patient simultaneously is a profound cognitive HFS, and it includes critical thinking, decision-making and problem-solving. HP performed most of their work with this triple role of teaching, learning and caring for patients and relatives. Several HP said they did not learn this skill in their education or as newly hired; they taught themselves to combine work with learning and implementing individually developed HFS.

An advanced nurse said, "*Although I have worked here for 1½ years and am competent, I must teach my new colleagues, care for patients, and seek guidance from the expert nurses. Nevertheless, sometimes I just want to work without integrating new stuff*." This quote described that HP must cope with this triple awareness to transfer new knowledge, reflect on and be ready to change behaviour and actions. Moreover, an expert nurse expressed that since the SBT, she has considered whether she should start teaching her new colleagues and students about this triple awareness. However, she felt she lacked competencies in how to do so.

Data showed an insignificant change for some HP from the clinical phase to the transfer phase. A competent doctor stated that through the SBT, he became aware of this complex task and tried to find a better way to balance his roles. An expert nurse expressed that she had taught herself to manage the balance of her triple role: "*Nobody has ever talked about this triple role or taught me how to do it; it's just how it is. It makes sense; working here is like that."* This finding suggests that HP were unaware of the more hidden HFS, although these significantly impacted their everyday work.

The analysis of this key theme revealed that if transfer of HFS from SBT to clinical practices should succeed, the individual must be ready to challenge their routines and behaviour, use the new skills, and deal with the constant need for triple awareness. In their own words, SBT helped them become aware of hidden HFS.

2. Intercollegiate transfer of learning: The characteristics of this theme were the intercollegiate responsibilities in training the new or changed behaviour and actions among colleagues after the SBT course. An example from the transfer phase showed this training in the clinic: *Two nurses walk towards each other in the hallway. An advanced nurse (N1) smiles at an expert nurse (N2), who slows and nods to N1. They stop and begin to coordinate and engage in joint decision-making.* They participated together in the SBT course. The nurses looked as if they communicated silently with their bodies and faces. When N1 smiled, N2 slowed down, and her nod was an invitation to N1 that she may interrupt N2. They did not coordinate with words but interpreted each other's embodied behaviour.

The theme was divided into three subthemes: a) Speaking HFS, b) Psychological safety, and c) Developing HFS together.

<u>2a. Speaking HFS.</u> The participants gained awareness and new ways to speak about HFS. A doctor and a nurse agreed: "*… we've talked about it [HFS] after the course and try to support each other to improve it, … but never with others; … it's difficult because they weren't there [in the SBT debriefings]*." This specified that they gained awareness and a way of talking about HFS, which they shared in close collegial relations, and that the SBT made them aware of the significance of HFS. Nevertheless, they shared this awareness and way of talking about HFS with colleagues they trained with, not broadly in the ward or with the managers. HFS thus became a distinctive skill for some HP. CEA showed this multiple times; one example is seen in Figure 7.

<u>2b. Psychological safety.</u> The participants mentioned the need to feel safe and secure in SBT, debriefings, and experiments using the new or changed behaviour in practice. An expert nurse declared: "*I only dare if I feel secure … trying the new stuff, you know, without feeling anxiety and the sense of being exposed or judged*." Some articulated that they considered SBT a privilege to train as a team and improve as a benefit for the patients. However, there were some barriers in the clinical setting. The colleagues primarily spoke with those whom they felt safe.

Some participants mentioned a mutual understanding that good SBT, debriefings and transfer demand an open feedback culture in the ward. However, it was a challenge "*… when the leaders don't show the way*", "*… if I don't feel safe among my colleagues*," or "*… when the personnel flow is this big*." This indicated that HP wanted to use and transfer the newly learned but struggled to succeed.

<u>2c. Developing HFS together.</u> The professional roles developed and became competency through interactions with colleagues, from novices to experts. In the SBT,

a competent nurse (N1) received a delirious, acute, sick patient. The competent nurse called an expert nurse (N2) to the room. N2 could have taken the lead but instead supported N1 in her leadership. N1 tells in the debriefing that she, simultaneously with the coordination and teamwork with the doctor, observes how N2 acts in the situation: "*Because I hope to become an expert like her*." This example demonstrated that HP learn and teach how to do effective teamwork when working as a team and that the less experienced gained support, a role model and experiences through their work. A doctor expressed: "*Simulation is one of the only places where we learn and reflect across the interdisciplinary barriers, and this makes us better as a team in difficult situations, not only the acute*."
HP expressed, across the data, that current HFS (ANTS) training is primarily an add-on to courses aiming at highly acute situations and algorithms. In this study, HP gained a new understanding of HFS through the three phases. Nevertheless, how HP spoke about HFS changed only among the SBT participants. From talking about HFS as closed-loop, teamwork and leadership, they spoke in the transfer phase about different ways of being aware in different situations, working with interruptions and balancing learning, teaching and working.

The analysis of this key theme expressed that if transfer of HFS from SBT to clinical practices should succeed, the colleagues must have a mutual awareness and a way to talk about HFS and keep practising, reflecting and supporting each other in the transfer process. This work demands psychological safety among HP, which is necessary for internalising the knowledge in the individual self and the ward.

3. Organisational transfer of learning: The characteristics of this theme were organisational awareness and focused on transferring HFS in areas other than acute situations. All participants expressed differently that the organisational support for the newly trained HFS transfer has yet to be adopted. A nurse said, "*No one asked me what I've learnt or need to implement … I'm on my own*." The organisation seemed to lack focus on implementing knowledge of HFS to become a competency.

This theme was divided into three subthemes: a) Awareness of HFS's impact on patient care, b) Equality between HFS and Technical skills and c) psychological safety and support.

<u>3a. Awareness of HFS's impact on patient care.</u> The findings implied a lack of organisational awareness towards HFS. In the transfer phase, competent and expert participants disclosed that when they do mandatory training, they train in acute and rare situations using different HFS tools, mainly focusing on leadership and communication (SBAR and Closed-loop). Moreover, they expressed that transfer of HFS in clinical practice is rarely in focus after a course. An expert nurse said: "*Sometimes the heads [leaders] underline the importance of SBAR and Closed-loop during clinical meetings. However, it's my responsibility to know how to change my routines, request it from my colleagues and teach it to the new ones*." The quote demonstrated the absence of awareness of the necessity of focusing on transfer after a course to integrate the new skills into competency. Furthermore, HP expressed that the workload and the individual responsibility of transferring the new skills to competency induced them to return to their usual routines and behaviour.

<u>3b. Equality between HFS and Technical skills.</u> Doctors and nurses mutually disclosed that there had been no organisational focus on HFS after the course, either in memos or meetings. HP had yet to hear which HFS the ward should implement or train

further. In contrast, both wards in the local hospital focused on implementing technical skills, such as using a new patient relaxing chair and a new machine to test blood samples. This indicated that technical skills were prioritised over HFS.

3c. Psychological safety and support. More participants expressed a need for support from the organisation to keep being motivated in the transfer process. A nurse said: "*When no one cares if I do it or not, why then use the energy? everyday is busy as it is*". Further, the findings indicated a deficiency in psychological safety as the HP only spoke with those they trained.

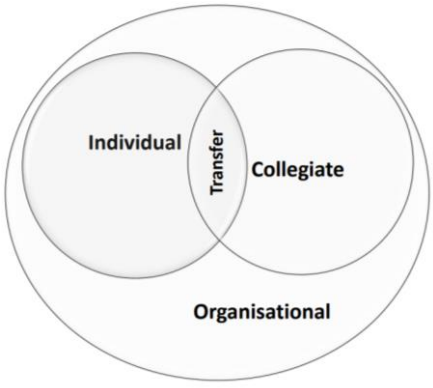
The analysis of this key theme showed that the wards involved in the project had yet to support the transfer of HFS at an organisational level despite the material given to the heads. The findings suggested that if transfer of HFS from SBT to clinical practices should succeed at an organisational level, the management must (in parallel with HP) gain awareness of HFS and increase their focus on HFS transfer. This is equally important as new guidelines, tools and procedures.

Critical analysis and discussion

Transfer from SBT to competency depends on three intertwined levels: an individual, an intercollegiate and an organisational level. This finding was consistent with existing research about transfer of learning, internalising, and retention of new skills (14, 35-38). However, transfer and retention of HFS are different from transfer of knowledge. Data implied that HFS are skills that can be taught and learned. HFS are, however, also embedded in the individual's personality, depending on one's history, culture and characteristics.

Integrating individual, intercollegiate and organisational processes is necessary to gain transfer, as shown in Figure 9. In the transfer process, the individual must be ready to learn, reflect upon one's actions, and try to change one's behaviour. Likewise, the intercollegiate must articulate HFS among each other to make HFS explicit and execute constructive feedback. The organisation surrounds the individual and the intercollegiate in the transfer process. The organisation is the HP's frame and condition; thus, the organisation must take the lead in the transfer process, nudge HP, and actively empower and support the individual and intercollegiate transfer process to complete implementation. Below, the three aspects of transfer are discussed. Additionally, retention and internalisation also demand an intercollegiate and organisational approach.

Figure 9: The threefold process leading to transfer of human factor skills



Individual transfer: The findings indicated behavioural changes in HFS among the individual SBT participants compared to the clinical phase. This was observed when a nurse in the transfer phase said she walked to see the doctor instead of calling him to avoid disturbing him. The analysis showed that throughout the day, the nurse needed to be consistently aware (situation awareness) of her interruptions of colleagues. However, she sometimes interrupted colleagues unnecessarily, yet she noticed it herself. The nurse had become consciously incompetent around some HFS. According to Dohn and Markauskaite (38), individual competency develops through transfer, resituation and transformation. The participant moves (transfers) knowledge from one context to another, adapting (resituation) the knowledge into a new context and integrating (transforming) this to one's competency. Transferring HFS from SBT to competency in clinical practice requires that the individual is ready to change behaviour and routines. One must have awareness, knowledge, language and understanding of HFS, reflect on one's behaviour and actions (39), and manage the triple awareness of learning, teaching and working. This demands a readiness for self-directed, lifelong learning (40) among HP. The lifelong learning concept can be used to understand HP's effort to apply their everyday work-life to transfer knowledge from SBT to competency. Adults only learn if they are ready to learn, can apply it to their social roles, add knowledge and skills to their experiences and problems, feel safe, and the skills are meaningful for their performance (41). This was evident in the data, e.g. around the administration of interruptions, which was one HFS the participants agreed upon; a reduction of interruptions could benefit patient safety and HP's well-being.

Intercollegiate Transfer: Transferring HFS also depended on intercollegiate relations and interactions. Transfer depended on HP's readiness to change the ward's way of working together (i.e., culture) and the level of psychological safety in the organisation (42). The findings indicated behavioural changes in the intercollegiate HFS after the SBT course; however, the changes were only observed in association with co-participants from the SBT course. The CEA microlens confirmed HFS transfer when comparing the example in theme 2 (the intercollegiate transfer) with a similar situation in the clinical phase, where the same two nurses met in the hallway. N1 asked N2 for help immediately after seeing N2 in the hallway. Similar situations with other personnel without the HFS SBT course showed the same reaction as N1 and N2 in the clinical phase, interrupting unreflectively. Elkjaer describes learning as a social process that includes actions and reflections on actions. New skills must be moved from the individual minds to the social sphere of interaction and practice (43). Furthermore, Wenger emphasises that adult learning relies on communities of learning in practice (44). This supports the data showing that colleagues participating in the course were more likely to discuss the HFS reflections' impact in the debriefings.

Further, the work environment significantly influences the transfer: HP and leaders must have a shared awareness and a way to talk about HFS to understand that HFS is used in the interactions between colleagues and patient care, and that adverse events can be reduced by improving HP's HFS (45, 46). The findings implied that HP mainly reflected on HFS with colleagues who participated in the same course, maybe due to a shared language and the extent of the psychological safety build-up within the course. This correlates with Edmonson's point about the need for psychological safety to develop in an organisation (47) to create a room for constructive peer feedback (48, 49) on behaviour and HFS in general. It is essential to act like a team continuously, not only in highly acute situations. The intercollegiate transfer of HFS depends on the individual transfer and vice versa; transfer can only happen in the presence of the intercollegiate.

Organisational transfer: Transfer of HFS from SBT demands an organisational approach. The analysis revealed that the focus on organisational transfer needs to be more present. One can wonder why hospitals overlook the transfer and internalising of HFS when they use billions of euros yearly in courses and education (50). Yamnill & Mclean state, "*Learning is of little value to organisations unless it is transferred in some way to performance*" (35,p.196). Transfer needs an organisational responsibility of the internalisation from theory and training to competency in clinical practice. The reasons could be multiple. The hospital's daily flow and operation are the organisation's key focus, but the need for competent HP is also mandatory. Hospital management seems to lack an awareness of HFS similar to the colleagues trained during the SBT course.

The findings showed a need for an increased focus on organisational transfer. Neither of the wards in the study trained or worked with implementing the newly learned HFS after attending the course. Still, the wards focused on transferring technical skills. Nokana points out that learning requires an interactive social process where tacit knowledge through explicit sharing can be internalised in an organisation (51). Nonaka's research strengthens the hypothesis that technical skills might be considered more valuable than HFS or that technical skills might be easier and more tangible than HFS. Technical skills training is individual skill and, consequently, not in the same degree dependent on intercollegiate or organisational transfer; it is a competence that the individual must gain and train. On the contrary, HFS are a social and interactive set of skills, which means that training must have an organisational focus on transfer to succeed and requires social and cognitive processes in the organisation (40). HFS can not, like technical skills, be put into an algorithm or procedure or be right or wrong, given that HFS depend on handling nonce events in a unique situation. Nevertheless, if HFS can be reflected upon in the intercollegiate and the organisation, then transfer and retention of HFS can be improved because individual HFS are embedded in the intercollegiate's competency and scaffolded by the organisation.

Without an organisational focus on the transfer process, transfer will only be individual, and the retention will be short. Several participants expressed that the lack of organisational focus entailed an effort to change their behaviour, and they returned to the usual way, although some individual skills were lasting. A doctor said, "*When I am the only one who tries to change, it's not worth the effort, and I give up.*" Retaining the new HFS will be impossible, and HP will return to their previous routines.

The organisation must know how transferring newly trained HFS impacts care and treatments. More participants pointed out that there was a comprehension of HFS as embedded innate skills or that it is only essential in acute situations. The analysis indicated that HFS was embedded in the individual but was trainable if explicated, reflected upon, and transferable. The leaders' responsibilities are to support and embrace HP and to lead and structure the transfer process after each course, not just tick the box if an employee has completed an HFS course. Before sending personnel on a course, a plan for the transfer process is necessary. Transformation and leadership are the key elements in transferring new HFS to competency.

In theory, these findings mean that it is possible to show how and if the transfer of newly trained HFS happens, although it is time-consuming. This study could form the basis of further research on transferring HFS and develop more straightforward ways to increase the focus on transfer. The findings mean that faculty planning a course must emphasise the organisational aspect of transferring HFS in clinical practice; the learning continues after the debriefings and is transformed into competency. The transfer to

competency can succeed through increased collaboration with the managers in clinical practice about who, what, and how learners can continue the training and intensify the implementation in the clinical practice. This study revealed the importance of involving all three levels (individual, intercollegiate and organisation) in transferring and implementing new learning, knowledge or equipment.

Limitation

This study has some limitations that need to be mentioned. First, due to COVID-19, data from the transfer phase was only collected from two wards instead of four and only from the small local hospital, in the ICU and emergency department. The findings could differ if transfer data were collected at all four wards. On the other hand, data from the clinical and SBT phases were similar, making it possible that data from the transfer phase would be consistent, strengthening the credibility of the findings. Second, the Hawthorn Effect represents a potential bias (52) in behaviour alteration due to observation. Third, there was a risk of potential selection bias because the SBT course was not mandatory. The Hawthorn effect and the potential selection bias weaken the credibility because the participants could act differently because they were watched. They accepted SBT as a learning method, and it cannot be assumed that their experiences, reflections and actions are representative (53). Nevertheless, video, physical and cognitive responses from the participants and fieldnotes reduce this bias as they allow going back and forth in the situations and discussions in the research group. Fourth, the hybrid method has an in-build validation, as the researcher has to go back-and-forth between units and the whole to verify if the assumptions stand. Further, analysis workshops were held with the research team throughout the analytical process to reduce misinterpretations and overinterpretations, increasing dependability. The findings' transferability is high because data are gathered in four different settings and environments. Also, these findings can be used in all kinds of transfer from teaching to competency. Finally, the data overrepresents nurses, minimising the insights into other personnel's transfer.

Conclusion

This study suggests that SBT of HFS can be transferred to competency in clinical practice. However, further focus on the organisational role and responsibility in implementing the HFS is needed if the competency should be more than a detached individual skill.

Findings suggest that SBT allows participants to talk about HFS and how to use HFS in their everyday clinical practice. There is a need to focus more on transfer to integrate the newly trained into competency in clinical practice and develop organisational learning by including clinical leaders. New HFS from SBT only leads to competency in clinical practice if a transformation plan and daily focus on using the new skills are carried out. Still, a more organisational view on training events is necessary if the competency is to become a culture rather than an individual skill.

More research on transfer to competency is necessary by executing follow-up fieldwork with participants, for instance, after a week, a month, and three months after the SBT.

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Declarations

Ethics approval and consent to participate

The SimLEARN study follows the present rules of responsible conduct of research, including the Helsinki Declaration and the Nuremberg Code.

All participants and facilitators received oral and written information about the study, could opt to decline participation, and gave informed consent. Psychological safety was addressed again on each day of data collection. Anonymity was ensured, and video files were stored confidentially. The Danish Data Protection Agency (ID

19/14608) and the Ethical Board of the Region of Southern Denmark (ID 20182000-140) approved the study.

Competing interests

The authors declare that they have no competing interests.

Acknowledgements

The authors declare no conflict of interest but disclose receipt of the following financial support for the research and authorship of this article.

Authors' contributions

Name	Lotte Abildgren	Malte Lebahn-Hadidi	Christian Backer Mogensen	Palle Toft	Sune Vork Steffensen	Lise Hounsgaard
Manuscript draft	X					
Conception and design	X	X			X	X
Method development	X				X	X
Collection and/or assembly of data	X	X				
Data analysis and interpretation	X	X			X	X
Figures	X					
Manuscript writing	X	X	X	X	X	X
Financial support (incl. grant writing)	X		X	X	X	X
Provision of study material or patients	X		X	X		
Infrastructure	X		X	X		
Administration (lab/funding)			X	X	X	X
Supervision			X	X	X	X

Paper A

Phenomenology and the Cognitive Sciences
https://doi.org/10.1007/s11097-021-09780-9

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

Malte Lebahn-Hadidi[1,2] · **Lotte Abildgren**[1,2,3] · **Lise Hounsgaard**[3] · **Sune Vork Steffensen**[1,4,5,6]

Accepted: 23 September 2021

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

✉ Malte Lebahn-Hadidi
lebahn@sdu.dk

Extended author information available on the last page of the article

Published online: 19 October 2021

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

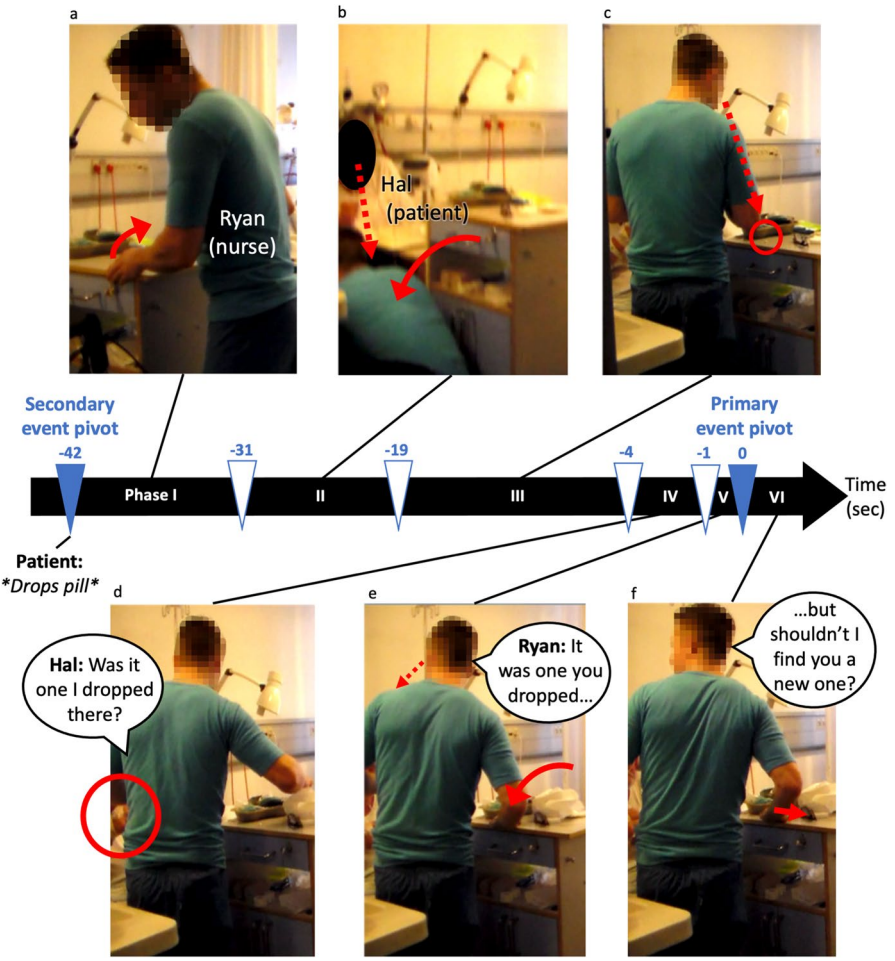

Fig. 1 The dropped pill. The timeline shows the key moments when the patient drops the pill and Ryan picks it up. Solid arrows indicate bodily movements; truncated arrows indicate gaze direction; circles indicate points of interest from an analytical perspective. The triangles on the cognitive trajectory 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

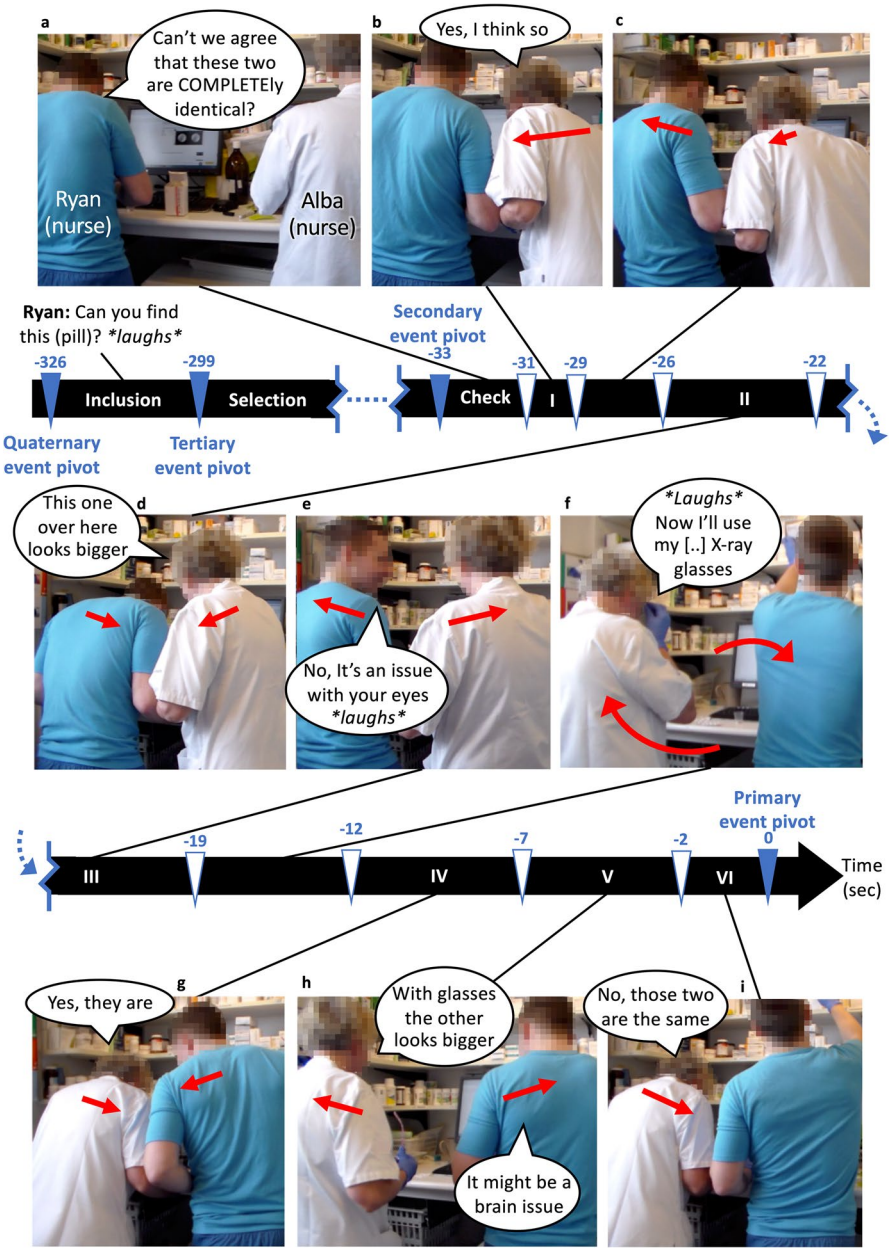

Fig. 2 Replacing the dropped pill. The figure shows the interaction of Ryan and Alba when they compare the size and shape of the contaminated pill and its replacement. Solid arrows indicate movement. Speech bubbles indicate the nurse's talk during the event

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

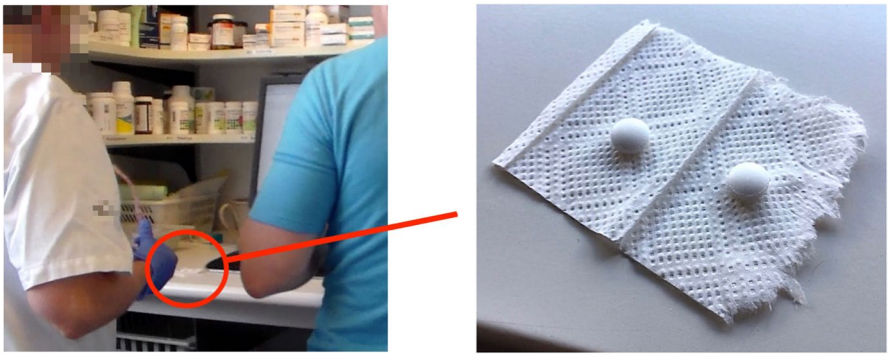

Fig. 3 The paper towel texture pattern provides an intrinsic scale for comparing the size of the pills. If the pills cover the same amount of ground texture, they appear to be the same width. The image on the right is a reconstruction using a paper towel from the actual ward, obtained 17 months after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

Acknowledgements This research is part of the SimLEARN project that investigates adverse events in two Danish hospitals and experiments with simulation training of human factors to avoid error. The project is funded by Hospital Sønderjylland Aabenraa, the Free Research Fund at Odense University Hospital, and the University of Southern Denmark. Data management infrastructure is provided by OPEN (Open Patient data Explorative Network) at the University of Southern Denmark.

Author contributions All authors contributed to the study conception and design. Data collection was prepared by all authors and performed by Malte Lebahn and Lotte Abildgren. The first draft of the manuscript was written by Malte Lebahn and all authors has commented on and edited versions of the manuscript. All authors read and approved the final manuscript.

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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Authors and Affiliations

Malte Lebahn-Hadidi[1,2] · Lotte Abildgren[1,2,3] · Lise Hounsgaard[3] · Sune Vork Steffensen[1,4,5,6]

[1] Centre for Human Interactivity, Department of Language and Communication, University of Southern Denmark, Campusvej 55, 5230 Odense M, Denmark

[2] Emergency Research Unit, Hospital Sønderjylland, University Hospital of Southern Denmark, Kresten Philipsens Vej 15, 6200 Aabenraa, Denmark

[3] Department of Clinical Research, University of Southern Denmark, Odense, Denmark

[4] Danish Institute for Advanced Study, Odense, Denmark

[5] Center for Ecolinguistics, South China Agricultural University, Guangzhou, People's Republic of China

[6] College of International Studies, Southwest University, Chongqing, People's Republic of China

Paper B

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

Malte Lebahn-Hadidi[1,2,3], Lotte Abildgren[2,4,5,6], Lise Hounsgaard[4,6,7], Christian Backer-Mogensen[2] & Sune Vork Steffensen[1,3,8,9,10]

Extended author information available on the last page of the article.

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[1]. 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 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

[1] 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.

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.

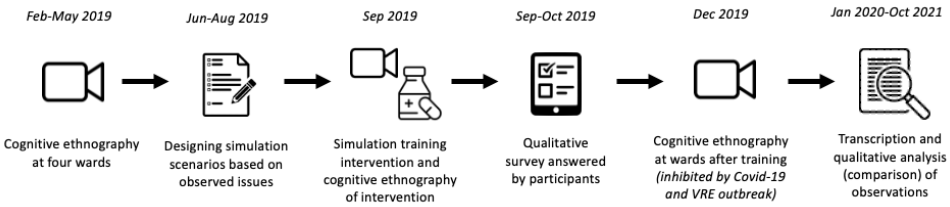

Figure 1: Study method steps

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.

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	Interruptions removes focus; Kind interruption clarification; Helping colleagues (checking);

	must clarify several times what Fie is referring to. Confirms inclusion. Conversation ends with micro-voicing strategy: humming and phasing out voice.	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)

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 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

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

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.

Authors and Affiliations

Malte Lebahn-Hadidi[1,2,3] (corresponding author: lebahn@sdu.dk), Lotte Abildgren[2,4,5,6], Lise Hounsgaard[4,6,7], Christian Backer-Mogensen[2] & Sune Vork Steffensen[1,3,8,9,10]

[1] Department of Language and Communication, University of Southern Denmark,

[2] Emergency Research Unit, Hospital Sønderjylland, University Hospital of Southern Denmark, Odense, Denmark,

[3] Centre for Research in Patient Communication, Odense University Hospital, Odense, Denmark,

[4] Department of Clinical Research, University of Southern Denmark,

[5] Anesthesiology and Intensive Care Unit, Odense University Hospital, Odense, Denmark

[6] OPEN, Open Patient data Explorative Network, Odense University Hospital/Department of Clinical Research, University of Southern Denmark, Odense, Denmark

[7] Department of Nursing & Health Science Nuuk, University of Greenland

[8] Danish Institute for Advanced Study, University of Southern Denmark, Odense, Denmark,

[9] Center for Ecolinguistics, South China Agricultural University, Guangzhou, PR China,

[10] College of International Studies, Southwest University, Chongqing, PR China

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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