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Patient Safety in Everyday Work

Learning from things that go right

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Abbreviations used in study:

DPSD	Danish Patient Safety Database
ETTO	Efficiency-Thoroughness-Trade-Off
FMV	FRAM Model Visualiser
FRAM	Functional Resonance Analysis Method
GP	General Practitioner
LEAN	A production philosophy with focus on waste and flow
RCA	Root Cause Analysis
RHC	Resilient Health Care
RHCN	Resilient Health Care Network
TETO	Thoroughness-Efficiency-Trade-Off
WAD	Work-as-done
WAI	Work-as-imagined
WHO	World Health Organisation

Preword

In August 2012, I signed up for a flexible master training program '*Master in Public Quality and Risk Management*' at the University of Southern Denmark. My Master Thesis will complete the training program.

The focus of my Master Thesis is to improve patient safety in complex health care systems by learning from things that go right in everyday work.

In the beginning of March 2016, I finished the last course in the training program at the University of Lund in Sweden. The topic was Patient Safety. The project work prepared during the course focused on certain aspect of everyday work, especially the cognitive style and abilities of people. The project work is included in my Master Thesis.

The findings of the thesis will be used in research articles, the next version of a handbook for the practical use of methods to describe complex systems and in an upcoming book about resilience. The title of the book is 'The Field Guide to Resilient Health Care' and the book focus on the practical use of tools to develop resilient organisations.

Middelfart, May 27, 2016

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Abstract

Traditionally, learning from failures, e.g. things that go wrong, has been the approach to improve patient safety in the Danish health care system. With increasing complexity of the system, this approach is getting less and less suitable to explain why patients experience harm while treated in the system. Leading safety experts, health care professionals and researchers point out the need to include learning from the performance of everyday work, e.g. things that go right. The title '*Patient Safety in Everyday Work, Learning from things that go right*' reflects the focus of this study.

The study investigates how a description of everyday work can be used to improve patient safety at public hospitals in the Southern Region of Denmark. The theoretical framework is a novel systemic approach to safety. The approach builds on the assumption that systems are complex and when things sometimes goes wrong it can be caused by other conditions than failures.

The key is to describe the performance of everyday work. In complex systems, people need to adjust what they do to the actual situation, often because of limitations in time, resources and information. People's adjustments normally ensure the safe and effective functioning of the complex system but result in performance variability. This variability can propagate through the system and sometimes result in an unexpected and unwanted outcome for the patient.

This study found that adjustments in everyday work in health care settings can be identified, described and understood by using the *Efficiency-Thoroughness-Trade-Off principle* and the *Functional Resonance Analysis Method*. An important factor is the involvement of and cooperation with the health care professionals doing the actual work. The study also found that the *Functional Resonance Analysis Method* unveils interactions and dependencies between activities in everyday work and can explain how performance variability can emerge into patient safety incidents. The study concludes that the description and explanation of adjustments in everyday work is a valuable platform to improve patient safety in health care settings.

Resumé

At lære af sine fejl, når noget går galt, har været den traditionelle tilgang til at forbedre patientsikkerheden i det danske sundhedsvæsenet. Med stigende kompleksitet passer denne tilgang stadig dårligere til at forklare, hvorfor patienter skades, når de behandles i sundhedsvæsenet. Ledende sikkerhedseksperter, sundhedsprofessionelle og forskere peger på nødvendigheden af også at lære af det, som går godt i det daglige arbejde. Titlen '*Patientsikkerhed i det daglige arbejde, At lære af det som går godt*' afspejler fokus for nærværende studie.

Studiet undersøger, hvordan en beskrivelse af det daglige arbejde kan anvendes til at forbedre patientsikkerheden på de offentlige sygehuse i Region Syddanmark. Den teoretiske ramme er en ny systemisk tilgang til sikkerhed. Tilgangen bygger på, at systemer er komplekse og når noget går galt, kan det skyldes andre forhold end fejl.

Det afgørende punkt er at beskrive, hvordan det daglige arbejde udføres. I komplekse systemer bliver mennesker nødt til at tilpasse, hvad de gør til de aktuelle forhold, ofte på grund af begrænsninger i tid, ressourcer og information. Tilpasningerne sikrer normalt, at det komplekse system fungerer sikkert og effektivt, men giver også variation i systemet. En variation, som kan forstærkes gennem systemet og nogen gange resultere i et uventet og uønsket resultat for patienten.

Studiet viser, at tilpasninger kan identificeres, beskrives og forstås ved anvendelsen af princippet for *Efficiency-Thoroughness-Trade-Off* og metoden *Functional Resonance Analysis Method*. Afgørende er involvering af og samarbejde med det kliniske personale, som udfører det faktiske arbejde. Studiet viser, at metoden *Functional Resonance Analysis Method* kan afdække samspil og afhængigheder mellem daglige arbejdsopgaver og kan forklare, hvordan tilpasninger kan ende med utilsigtede hændelser. Konklusionen er, at en beskrivelse og en forklaring på tilpasninger i det daglige arbejde er en værdifuld platform til at forbedre patientsikkerheden i sundhedsvæsenet.

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1. Introduction

Good quality health care is something providers aim for all over the world, also the public hospitals in Denmark.

In 2006, the World Health Organisation (WHO) stated that good quality health care has six dimensions: *Effective, Efficient, Accessible, Acceptable & Patient-centred, Equitable and Safe*. The definition of the dimension '*Safe*' is '*delivering health care which minimizes risks and harm to service users*'. [WHO, 2006]

In 2004, the Danish Government passed the *'Law of Patient Safety*' enhancing a systematic approach to improve patient safety by learning from failures, e.g. things that go wrong. After more than 10 years, patients still experience harm while being treated at public hospitals in Denmark. Leading safety experts, health care professionals and researchers are questioning the approach to learn merely from '*things that go wrong'*, pointing out the need to include learning from '*things that go right'*, e.g. the performance of everyday work. [Ball et al, 2015][Hollnagel et al, 2015]

This study focuses on improving patient safety in health care settings by learning from things that go right in everyday work.

2. Background

2.1 What we know

The aim to ensure safe health care is not new and goes a long way back in the history of medicine. The start is often credited to Florence Nightingale in the mid-1800s. One[1] of her famous quotes is '*The very first requirement in a hospital is that it should do the sick no harm*'. [Mainz et al, 2011]

Even earlier, the English physician, Thomas Sydenham[2], who lived from 1624 to 1689, is quoted for '*Primum non nocere'* (Author: Above all, do no harm).

In June 4, 2004, the Danish Government passed the '*Law of Patient Safety'*. The law obliged health care professionals at public and private hospitals to report

[1] Florence Nightingale, Notes on Nursing: What It Is, and What It Is Not

[2] http://www.ncbi.nlm.nih.gov/pubmed/15778417

patient safety incidents and to learn from the reported incidents, both on an individual and organisational level. With the law Denmark became the first country in the world to legislate about patient safety incidents. In 2010, the government extended the obligation to report incidents to all health care providers in the Danish Health Care system, including the communities. In 2011, patients and relatives gained the right to report their experienced incidents. [Danish Ministry of Health, 2014b]

Today the law has become an integral part of the Danish Health Care Act and the Danish Accreditation Program for Hospitals. [Danish Ministry of Health, 2014a] [DDKM, 2009] [DDKM, 2012]

The health care professionals report all the patient safety incidents to a national Patient Safety Database (DPSD). The reporting includes incidents that resulted in harm to the patient; incidents that could have resulted in harm to the patient and near misses, where the incident did not reach the patient. [DPSD, 2015a] [Danish Ministry of Health, 2014a]

The purpose of the DPSD was to establish '*a system to analyse and communicate knowledge about causes of risk situations*'. The system relates to '*human and technological failures, but also organisational factors affecting the occurrence of patient safety incidents*'. The underlying assumption was that analyses of reported incidents and failures and communication of knowledge about risk situations would improve patient safety in general. [Danish Ministry of Health, 2014b]

The functioning of the system had and still has two important conditions. Firstly, that the health care professionals are willing to report. Secondly, that the health care professionals and organisations learn from the reported incidents.

In the first years from 2004, the focus was on motivating health care professionals to report, e.g. to create a culture of reporting. To support motivation the focus was on system failures instead of human failures. In addition, health care professionals could report anonymously. On the other hand, the system allowed no legal sanctions against the reporter exclusively based on reports in the DPSD. The system also enhanced feedback to the reporter and staff in general. After 2009, the focus gradually changed from reporting to learning from the incidents. [Danish Ministry of Health, 2014b]

In 2004, the health care professionals from the public hospitals in Denmark reported 6,000 patient safety incidents. By 2009, the number increased to 30,000. Today the number remains stable at 50,000 reports yearly. Since the start of the national reporting system, no health care professionals have been prosecuted based exclusively on reports in the DPSD. In 2014, 0.77 % of the reported incidents were classified fatal and 4.66 % as severe, e.g. shortening life expectancy, causing major permanent or long term harm or loss of function. [Danish Ministry of Health, 2014b] [WHO, 2009] [DPSD, 2016]

In spring 2014, 10 years after the reporting system was established, the Danish Government decided to examine the effect of the system. The purpose was to identify opportunities for improving the system, but also to support the shift in focus from reporting to learning. The government published the status report in July 2014. The conclusion was that a reporting culture was well established, the number of reports was satisfactory and no further actions needed. However, the report mentioned that the 2009 shift from reporting to learning still needed to be enforced. A chapter was dedicated to the understanding of why incidents happen. The chapter presented that to learn from '*things that go right'* is a valuable approach in addition to learn from failures. [Danish Ministry of Health, 2014b]

2.2 Why it is interesting

Back in 2004, when the first patient safety law was passed, the assumption that health care is a linear system dominated the safety thinking, e.g. if something goes wrong it is caused by a failure in the system. In this thinking, known as *Safety-I*, a system consists of components and failures are components that did not work as supposed to or had stopped working. The component may be technical equipment, organisation or people. The key to improve patient safety is to analyse patient safety incidents, to find the component that malfunctioned and to eliminate the cause. If elimination is not possible, barriers must be build, so that the malfunctioning not reaches the patient. [Danish Ministry of Health, 2014b]

As health care systems get more and more complex, the assumption of linearity is less and less suitable to explain why things go wrong. The safe and effective functioning of the systems depends on the behaviour of people in the system. This dependency makes complex systems non-linear, e.g. cause and effect chains can no longer explain things that happen in the system. Thus, improving patient safety must include learning from *things that go right,* e.g. how people perform everyday work. From this argument, a different way of thinking, known as *Safety-II*, has emerged. The Safety-II thinking builds on the assumption that systems are complex and when things go wrong it can be caused by other conditions than failures. [Hollnagel, 2009] [Hollnagel, 2014] [Hollnagel et al, 2013] [Wears et al, 2015]

The WHO statement *'health is a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity'* reflects nicely the change from focusing merely on '*things that go wrong'* to focusing on '*things that go right'*. Patient safety is not just the absence of patient safety incidents but also the presence of a safe and effective functioning health care system.

In complex systems, people need to adjust what they do to the actual situation, e.g. resources/information/time available, working environment, conditions determined by how other people perform their work and the person's own cognitive style and ability (thinking, remembering or problem solving). [Hollnagel, 2009] [Hollnagel, 2012b] [Hollnagel, 2012c] [Akselsson, 2014].

An important theory to understand adjustments is the '*Efficiency-Thoroughness-Trade-Off* 'principle (ETTO). The ETTO principle describes how people in their everyday work must balance between efficiency and thoroughness. Adjustments reflect this trade-off. An example of such a trade-off is a person that in a work situation skips a test because the person believes to know that someone else will check it later. The person saves time by skipping the test. Instead of being thorough, the person is effective. The person trades-off thoroughness with efficiency. [Hollnagel, 2009] [Akselsson, 2014]

Adjustments of everyday work normally ensure the safe and effective functioning of the system, but can also lead to an unwanted and unexpected outcome. The adjustments result in performance variability that can propagate through the system. Sometimes the variability is dampened. Sometimes it becomes unusually large because of the unintended interaction of the performance variability. The latter is known as '*functional resonance*'. Functional resonance explains why things that normally go right sometimes can go wrong. [Hollnagel, 2012a] [Akselsson, 2014]

The need to improve patient safety by learning from things that go right raises some basic questions: How can the adjustments be seen and described? Why do adjustments that are intended to improve performance sometimes emerge into an unwanted and unexpected outcome for the patient? How does the insight into adjustments support management and health care professionals to identify opportunities for improving patient safety in everyday work?

3. Problem, purpose, research question and limitations

3.1. Problem and purpose

The problem has yet to be solved of how public hospitals can improve patient safety in everyday work by learning from things that go right, both on an individual and organisational level.

The purpose of this study is to investigate how health care professionals normally adjust everyday work to ensure the safe and effective functioning of the system and how the result of the investigation can be used as a platform for identifying opportunities for improving patient safety in everyday work in health care settings.

3.2. Research question

This study aims to answer the research question:

Question: How can the description of adjustments of everyday work be used to improve patient safety in health care settings?

To answer the research question the study will investigate:

1. How can the adjustments of everyday work be seen and described?
2. How can the adjustments of everyday work sometimes emerge into an unwanted and unexpected outcome for the patient?
3. How does the insight into the adjustments support management and health care professionals to identify opportunities for improving patient safety in everyday work?

3.3. Limitations

The study is limited to health care settings at public hospitals in the Southern Region of Denmark and is based on data collected in the time from March 2012 to February 2016.

4. Theoretical framework, definitions

Health care is a complex system, where things happen or change quickly and where demands and resources often are unpredictable. A system, where people have to be mindful and remain sensitive to the possibility of failures. [Hollnagel, 2012c]

The focus of this study is to improve patient safety by investigating how everyday work normally is performed in health care settings. The study is an empirical study, based on qualitative data.

4.1. Theoretical framework

The Safety-II thinking offers a theoretical framework to describe how complex systems work. The thinking emerged from the traditional thinking of Safety-I, because the Safety-I thinking was insufficient to explain why things sometimes go wrong in complex and non-linear systems. Safety-II is well described in the international safety literature and was chosen as theoretical framework due to the focus on safety and the functioning of complex system. The application of Safety-II thinking in health care is in the literature known as '*Resilient Health Care*' (RHC). [Hollnagel et al, 2011] [Hollnagel et al, 2013] [Hollnagel, 2014] [Hollnagel et al, 2015] [Wears et al, 2015].

In Safety-II, the basic tools to explain how complex systems work is the ETTO principle and the phenomenon functional resonance. The ETTO principle can explain the behaviour of people and the functional resonance why things that normally go right in a complex system sometimes can go wrong. The FRAM is an analysis method developed in the Safety-II thinking paradigm to describe how everyday work is actually performed and model how adjustments in everyday work can emerge into an unwanted and unexpected outcome for the patient, e.g. functional resonance. Chapter 2 has introduced the ETTO principles and the FRAM. [Hollnagel, 2009] [Hollnagel, 2012a]

4.2. Definition of terms

Table 1 defines the most common terms used in this thesis.

Table 1 Definition of terms

Term [Reference]	Definition
Coupling [Hollnagel et al; 2014] [Perrow, 1999]	Coupling describes the degree to which functions interact and depend upon each other. The degree of coupling can range from loose to tight.
Function [Hollnagel et al; 2014]	A function refers to the activities that are required to produce a certain outcome. A function describes what people – individually or collectively – have to do in order to achieve a specific aim. A function can also refer to what an organisation does or what a technical system does either by itself or in collaboration with one or more people
Model [Hollnagel et al; 2014]	A model describes a system's functions and the potential coupling between functions. The model can visualize the actual couplings that may exist under given conditions (an instantiation)
No harm incident [WHO, 2009]	An incident, which reached a patient and resulted in no harm to the patient
Patient Safety [WHO, 2009]	Patient safety is the reduction of risk of unnecessary harm associated with healthcare to an acceptable minimum
Patient safety incident [WHO, 2009]	A patient safety incident is an event or circumstance that could have resulted, or did result, in unnecessary harm to a patient. The use of the word "unnecessary" in this definition recognizes that errors, violation, patient abuse and deliberately unsafe acts occur in healthcare
Performance variability [Hollnagel et al; 2014]	Performance of a function is always variable in complex systems because the conditions for doing the function always vary
Resilience [Hollnagel et al; 2014]	A system is said to be resilient if it can adjust its functioning prior to, during, or following changes and disturbances, and thereby sustain required operations under both expected and unexpected conditions
Patient safety intervention [WHO, 2009]	An intervention focusing on improving safety for patients while being treated in a health care system

4.3. Literature search

Two important sources of literature in the field were books addressing the theoretical framework in this study and literature listed at the homepage of the two international networks *Resilience Health Care Network* (RHCN) and *FRAMily*:

- ✓ *RHCN,* an international network of researchers and health care professionals. The network meets once a year in different countries. The first meeting was in 2012. The purpose of the network is to facilitate the interaction and collaboration among scholars and practitioners who are interested in applying Resilience Engineering to health care: www.resilienthealthcare.net.
- ✓ *FRAMily*, an international network of people across high-risk domains working with the application of the FRAM modelling and analysis. The network meets once a year in different European countries. The first meeting was in 2006: www.functionalresonance.com

In addition, a preliminary literature search was completed September 16, 2015, at the University Hospital in Odense. A broader literature search was completed April 8, 2016, at the library at the University of Southern Denmark. The purpose of the latter was to get an update on relevant international literature, especially peer reviewed articles, to confirm the findings in this study. A librarian supervised both searches. Appendix A shows the key words and the search databases included.

5. The method

At the hospitals in Denmark, a very common method to analyse patient safety incidents has been and still is the Root Cause Analysis (RCA). The first version of the Danish Accreditation program in hospitals recommended the method to analyse patient safety incidents. The RCA is based on the Safety-I thinking and seeks to find the component that malfunctioned. The method assumes that there is a root cause for any accident, as long as we look hard enough. [DDKM, 2009] [Akselsson, 2014]

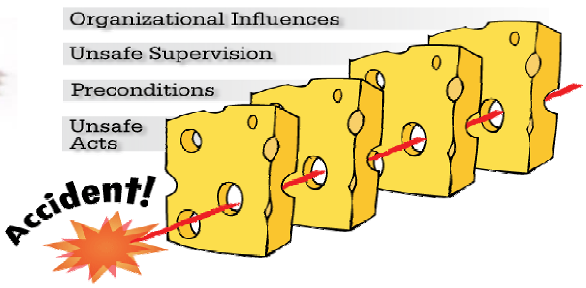
In the Safety-II thinking, an identifiable root cause to explain an incident may never be found and adjustments of everyday work is the key to improve patient safety. The aim of this study is to look closely into these adjustments. The FRAM is chosen to investigate adjustments of everyday work in health care settings and how they can emerge into an unwanted and unexpected outcome for the patient [Hollnagel, 2009] [Hollnagel, 2011] [Hollnagel, 2012a] [Hollnagel, 2013].

5.1. FRAM - Functional Resonance Analysis Method

The FRAM is well described theoretically and is used in different high risk domains like Health Care, Aviation, Maritime, Railway Traffic, Mining and Nuclear Power [Hollnagel, 2012a] [Hollnagel et al, 2014] [Clay-Williams et al, 2015].

The underlying accident model for the RCA is the '*Domino Bricks'* and the '*Swiss Cheese*'. The '*Domino Bricks'* metaphor visualizes that an accident is a result of a chain of events where an event is caused by the previous event. The '*Swiss Cheese'* is a metaphor visualizing how an unsafe act in combination with latent conditions in the different layers in the system, e.g. the cheese holes, can lead to accidents. See figure 1.

Figure 1 The 'Domino Bricks' and the 'Swiss Cheese' accident model



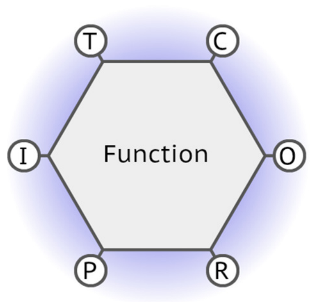
The FRAM has no underlying accident model. As part of the FRAM analysis a model of the actual work situation is build and used for the analysis. Instead of an underlying model, the FRAM is based on four principles: [Hollnagel, 2012a] [Hollnagel et al, 2014]

1) *'Equivalence of successes and failures':* People and organisations must adjust to the current conditions in everything they do. The adjustments are the reason why everyday work is safe and effective, but also the reason why things sometimes go wrong
2) *'Approximate adjustments':* Because time, information and resources always are finite, people must balance between efficiency and thoroughness. Due to this balance, the adjustments will always be approximate

3) *'Emergence':* Outcomes of an actual work situation is emergent because the conditions that could explain them are short-lived, e.g. a pattern that existed at one point in time. Therefore, outcomes cannot be traced back to the original conditions
4) *'Functional Resonance':* The variability of a person's work can merged or interact with the variability of what others do in the system, and increase the variability of the person's work, known as functional resonance.

The FRAM is used to describe how everyday work is actually performed, known as '*work-as-done*'. The gap between work-as-done and how the work is planned to be performed, known as *work-as-imagined,* reflects the adjustments that people need to do to ensure the safe and effective functioning of the system. The work consists of functions '*To do something*'. The description includes how the functions in an actual work situation interact with and depend on each other in both expected and unexpected ways. Each function is described in detail through six aspects: I=Input, O=Output, R=Resources, C=Control, P=Precondition and T=Time, and visualized by a hexagon with one aspect in each corner of the hexagon, see figure 2. Appendix B describes the aspects in detail. [Hollnagel, 2012a] [Hollnagel et al, 2014]

Figure 2 Visualization of a function with its six aspects



The adjustments of everyday work result in performance variability of the output of a function. The potential variability depends on the type of function and the variability of the functions providing the aspects Input, Resource, Control, Precondition and Time. There are three types of functions: Human functions, Technical functions, Organisational functions. The variability depends on the function itself and the environment. [Akselsson, 2014] [Hollnagel, 2012a] [de Ward et al, 2010]

Table 2 shows the different characteristics of the three types of functions and the expected variability.

Table 2 The characteristics and variability of function types

Technological functions	Human functions	Organisational functions
Carried out by various types of 'machinery'	Carried out by humans, individuals or small, informal (social) groups	Carried out by a group or groups of people, sometimes very large groups with explicitly organisation of tasks
Designed to be highly predictable and reliable	Respond very quickly to changes, not least in the interaction with others	Defined and described on the level of organisation
Can vary due to (ambient conditions, software peculiarities, inadequate maintenance	Can vary due to many different things	Can vary to definition and description
Performance variability normally low	Performance variability can change rapidly from moment to moment with the potential of resonance	Performance variability changes slowly with the potential of resonance

A FRAM analysis is prepared in five steps [Hollnagel, 2012a]:

0) Determine the purpose and scope of the analysis
1) Identify and describe the functions
2) Describe potential and actual performance variability
3) Aggregation of performance variability
4) Propose ways to control variability

The initial step 0 determines the purpose and scope of the FRAM analysis and sets the scene. This step is important to be able to limit the FRAM model prepared in step 1. In step 1, the functions that are required to describe the work situation are identified and data for describing the functions are collected through semi-structured interviews of the health care professionals performing the actual work. The output from step 1 is a FRAM model.

In step 2, instantiations of the FRAM model are prepared, showing how the functions couple under given conditions. For patient safety incidents, the instantiation typically covers the time framework of the incident and represents the conditions that existed at that time. For risk assessment and the need to understand everyday performance or possible effect of a change, a set of instantiations is appropriate. In step 3, the possible outcomes for at given instantiation is assessed giving the basis for understanding how variability can either increase (functional resonance) or decrease (dampened). In step 4, recommendations for actions, effective control strategies or monitoring are developed.

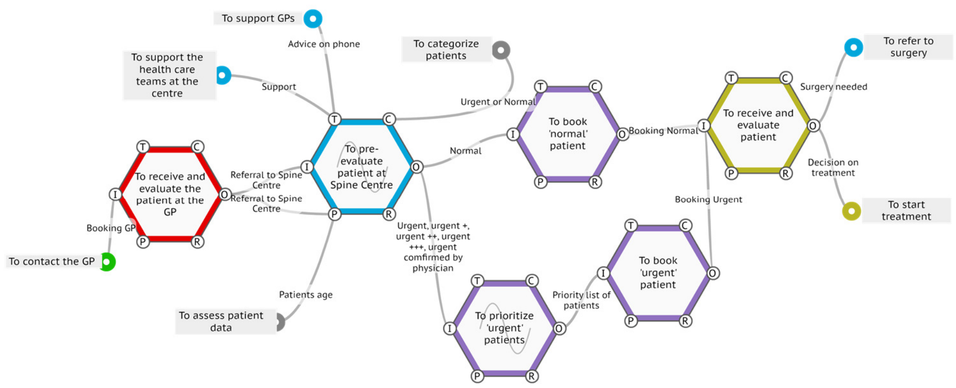
This study mainly focuses on the use of the FRAM to see and identify adjustments in everyday work and to model everyday work to inform our understanding of how the adjustments affect the patient outcome.

5.2. The modelling of everyday work

In addition to the verbal description, a model of everyday work is built with the FRAM Model Visualiser (FMV) in this study. The model demonstrates how performance variability can propagate through the functions in the system. The purpose and scope of the FRAM analysis limit the expansion of the model to the functions needed to describe the work. In this study, the FRAM model is the basis to understand how the adjustments of everyday work can emerge into an unwanted and unexpected outcome for the patient and to identify opportunities for improving patient safety in everyday work [FMV, 2014] [Hollnagel et al, 2014].

Figure 3 is an example of a FRAM model. The model shows how the functions involved couple. Chapter 6.3.3 of this study explains the shown model in details.

Figure 3 Example of a FRAM Model



5.3. The data collection

From March 2012 to February 2016, the author of this study was involved in about 30 FRAM analyses. The analyses were initiated for different reasons: Investigation of a patient safety incident, a need to understand everyday performance and assessment of the potential and actual effect of a change. All the analyses had one thing in common: the health care professionals' wish to learn from things that go right in everyday work, instead to wait for a failure to occur. Four of the FRAM analyses are included in this study. They were selected for the study because the results are not confidential and the author was responsible for planning, conducting and documenting the FRAM analyses, including the modelling and the feedback to the health care professionals.

Table 3 describes the four FRAM analyses. The first column is the identification number, the second column describes the year of the FRAM analysis and the third column the title. The fourth column includes the scope and the fifth column describes the purpose of the FRAM analysis (step 0 in the FRAM analysis).

Table 3 Description of the four FRAMs included in the study

No.	Year	Title	Scope	Purpose
FRAM 1	2013	Ward Rounds	The ward rounds in the Geriatric ward in one specific hospital	To describe everyday work and how the work affects the length of stay in the ward
FRAM 2	2013	Spine fracture	The pathway of the patient through the General Practitioner (GP) and hospital units until the point where the unstable spinal fracture was unveiled.	To describe everyday work to explain how a reported patient safety incident could happen and to identify opportunities for improving patient safety
FRAM 3	2013	Pre-evaluation of patients	The pre-evaluation of patients with back pain at a Spine Centre	To describe everyday work to understand performance variability of the pre-evaluation despite a standardized procedure
FRAM 4	2014	Blood-sampling	The patient pathway from arriving at the blood clinic to the point where the patient enters the blood sampling room	To describe everyday work to explain why the expected increase in productivity was not achieved in a LEAN project

5.3.1 Semi-structured interviews

In step 1 of the FRAM analysis, data on performing everyday work are collected through semi-structured interviews of the people doing the work, individually or in groups of two to three persons. The interviews are semi-structured to enhance a dialogue between the interviewer and the informant resulting in a nuanced picture of how the work is performed, including workarounds, shortcuts and other adjustments. The semi-structured interview also gives the freedom to ask the questions in natural order and to follow-up or go into detail of specific questions [Brinkmann et al, 2010].

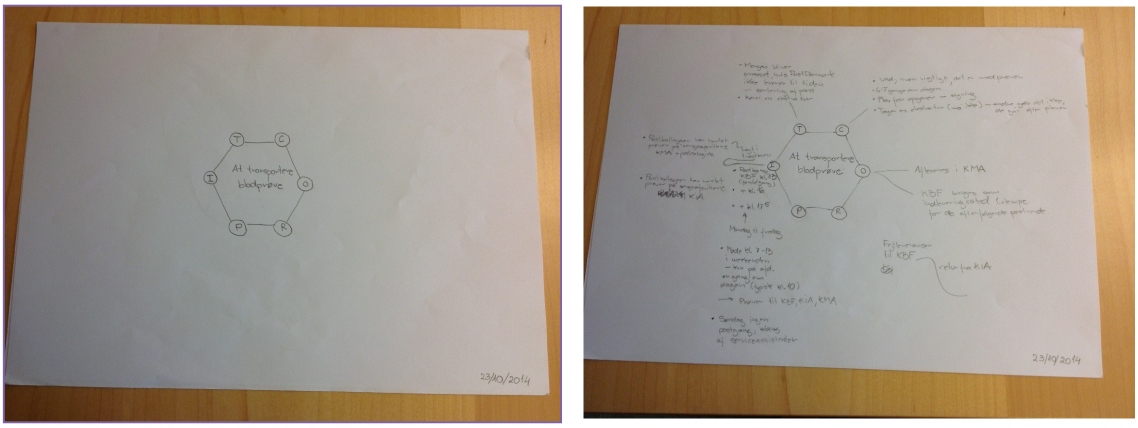
In order to reduce the gap between what people think they do and what they actually do, the interviews are performed at the actual workplace. If not possible, a tour of the workplace is included to give the interviewer a feeling for the environment. The interviewer may bring a valuable set of 'new' eyes to things that the health care professionals do not see anymore.

The interviews address functions (to do something) in the workflow, identified through review of documentation like procedures or instructions, through interviews with managers or through description of a reported patient safety incident.

A questionnaire, based on a function's six aspects: Input, Output, Time, Precondition, Control and Resources, guide the interviewer. The questionnaire covers the performance variability of the output and the interactions with and dependencies of other functions in the actual work situation. Appendix C shows common questions.

The interviewer uses visual facilitation to support the reflection of the informants on their everyday work. An A3-paper with the function in focus is placed in front of the informant during the interviews. The interviewer notes the information on the paper, visible for the informant. The informant can correct the notes and give additional information. In this way, the informant can validate the notes during the interview. Figure 4 shows the A3-paper at the start of the interview and the same A3-paper with notes at the end of the interview. [Gray, 2007]

Figure 4 The A3-paper with the function in focus with and without notes



The interviews in this study were *not* digitally recorded, in order to ensure a safe and trustful environment between the interviewer and the informant. The notes were typed in Danish after the interviews. Appendix D shows an example.

The data from the interviews were organised into the six aspects of FRAM. An inductive interpretive analysis of transcribed interview and observation notes was undertaken to identify key themes associated with the six aspects of FRAM, work-as-imagined and work-as-done. [Brinkmann et al, 2010] [Hollnagel, 2012a]

5.3.2. Narrative stories

Narrative stories about the health care professionals' experiences are collected through the FRAM analyses [Brinkmann et al, 2010].

5.3.3. Selection of informants

The health care people doing the actual work, is the main data source for describing '*work-as-done*' in the FRAM analysis. The recommendation is that informants are experienced people. They know everyday work, typical workarounds and shortcuts, the local culture and habits. Newly employed people or inexperienced people reflect often how work is done according to procedures or how a similar work was done in a previous position. In this study, the informants were experienced health care professionals with exception of one informant. [Hollnagel et al, 2014].

Table 4 shows the selected informants and the number of interviews in the four FRAM analysis.

Table 4 The selected informants and number of interviews for the four FRAM analysis

No.	Title	Informants	Number of interviews
FRAM 1	Ward Rounds	1. one senior physician 2. two junior physicians 3. two nurses	3
FRAM 2	Spine fracture	1. one General Practitioner 2. one surgeon and one medical secretary 3. three radiologists 4. one embryologist 5. one physician and one medical secretary	5
FRAM 3	Pre-evaluation of patients	1. one physician 2. one medical secretary 3. one physiotherapist 4. one occupational therapist 5. one nurse	5
FRAM 4	Blood-sampling	1. two managers 2. one phlebotomist 3. one newly employed phlebotomist 4. one receptionist 5. one laboratory assistant	5

Good practise in qualitative research is to increase the number of informants until no additional information is obtained [Brinkmann, 2010]. A challenge when preparing a FRAM analysis is the access to health care professionals doing the actual work, especially the physicians. In the FRAM 3, see table 4, six physicians pre-evaluated patients with back pain. There was only access to one physician because of shortage in staffing. To get a picture of the performance variability of the function 'To pre-evaluate patients at Spine Centre', four persons that used the output from the function were selected for interviews (one medical secretary, one physiotherapist, one occupational therapist and one nurse). This gave a picture of the performance variability of the physician's work and saved the physician's the time.

The conditions for doing the work in a specific health care setting is similar for the people in the system. The main differences in the way people do the work depend on experiences, skills, cognitive abilities and their decision on adjustments in the actual situation.

Everyday work is well-established routines that have shown effective, resulting in the wanted patient outcome most of the time. The routines reflect the culture and have deep roots in the organisation. The expectation is therefore that everyday work changes slowly.

To keep the number of informants down a larger group of health care professionals involved in the actual workflow calibrates the actual FRAM model (work-as-done). If possible, in a common meeting that allows a reflective dialogue. In the above-mentioned FRAM 3 analysis the FRAM model was presented to all the six physicians for calibration, since only one of the physicians was interviewed. Alternatively, reported patient safety incidents can calibrate the FRAM model because the model must be able to explain the incidents. [Gray, 2007]

This study is not required notified to the Danish Data Protection Agency, because the data cannot be traced back to identifiable persons.

6. Result of data collection

As mentioned in chapter 5.1, a FRAM analysis is prepared in five steps. Chapter 6 describes the result of the step 1 of the four FRAM analyses, included in this study. Table 3 in chapter 5.3 described scope and purpose of the four FRAM analyses.

Chapter 6.1 describes examples of identified adjustment in different functions in the four FRAM analyses. In chapter 6.2, a FRAM model for each case is modelled by using the FMV. The models are the basis for step 2, 3 and 4 in the FRAM analyses. Chapter 7 describes these steps.

6.1 Identifying and describing adjustments of everyday work

One way of identifying adjustments in everyday work is to compare how the work was expected to be performed - the '*work-as-imagined*' (WAI), and how the work is actually performed – the '*work-as-done*' (WAD).

The data source for '*work-as-imagined*' is written policies, procedures and instructions, interviews of managers and expressed or not expressed expectations from management and other colleagues. The source for '*work-as-done*' is the people actually performing the work.

Table 5 shows examples of adjustments found in the four FRAMs. The first column lists the identification number of the example and the related FRAM, the second column describes the function where the adjustment was identified, the third column describes '*work-as-imagined*' and the fourth column '*work-as-done*'.

Table 5 Examples of adjustments

Example no.	Function	Work-as-imagined	Work-as-done
Example 1.1 FRAM 1	*To do ward round* The ward round is a cooperation between the physician in charge and the nurses at the ward	The ward round starts when the nurses and the physician in charge are prepared	The ward round starts when the nurses and the physician in charge are prepared and they have found each other, normally somewhere between 9 am and 12 midday
Example 1.2 FRAM 1	*To do ward round* Different physicians are in charge of the ward rounds during the week	Common criteria for setting the date and time of discharge are defined	Common criteria are not defined and the physicians use their own criteria for setting the date and time of discharge
Example 2.1 FRAM 2	*To pre-evaluate patient at Spine Centre* Six different physicians prepare the pre-evaluation at the Spine Centre.	The physician assesses all the patient's test results during pre-evaluation	The physician only assesses the General Practitioner's (GP's) written referral and the age of the patient. This is normal procedure for all the six physicians
Example 2.2 FRAM 2	*To prepare report* A hospital unit prepares and assesses CT-scan to confirm suspicion of cancer. A report with the test result is forwarded to the patients General Practitioner (GP)	The GP expects that the heading of the test result include all findings, both the main finding related to the suspicion of cancer and incidental findings that need action to be taken	The heading include only the main finding related to the suspicion of cancer and not incidental findings. This is normal procedure at the hospital unit.
Example 2.3	*To read test result*	The hospital unit preparing the CT scan expects the GP	The GP only reads the heading of the test

FRAM 2	The General Practitioner (GP) assessment of a CT-scan due to the suspicion of cancer	to read the full text of the test result report	result report. This is normal procedure.
Example 3.1 FRAM 3	*To pre-evaluate patient at Spine Centre* The pre-evaluation is prepared by six physicians and the result of the pre-evaluation is to categorize the patients	The six physicians all work according to the written procedure, categorizing the patients as '*Urgent*' or '*Normal*'	The six physicians have expanded the category '*Urgent*'. Some follow the written procedure. Some uses '*Urgent* +', '*Urgent* ++', or '*Urgent* +++'. Some inform the medical secretary verbally that a patient is more urgent than all other patients categorized as '*Urgent*'
FRAM 3 Example 3.2	*To book patient* The medical secretaries book time for the patients according to the result of the pre-evaluation	The patient in the category '*Urgent*' are book in chronological order	A patient categorized '*Urgent*' will normally be overtaken by patients categorized as '*Urgent* +', '*Urgent* ++', ' *Urgent* +++' or if the physician inform the medical secretary verbally that a patient is more urgent than all other patients categorized as '*Urgent*' are.
FRAM 4 Example 4.1	*To find prescription* A precondition for taking a blood sample is a prescription, prepared by a physician in the electronic system	The receptionist in the blood clinic can always find a prescription in the electronic system when a patient arrives to the clinic	Every day prescriptions are missing. The receptionist uses time to find the prescriptions to avoid sending the patients home empty-handed
FRAM 4 Example 4.2	*To go to blood sampling room* On arrival to the blood clinic, the patient receives a queue number.	All patients can use the information on the screen and find their way to the	Certain groups of patients cannot use the information on the screen. The receptionist therefore

	The queue number will come up on a screen in the waiting room and 'tell' the patient to which blood sampling room they have to go to for the blood sampling	blood sampling room	keeps an eye on the screen, reminds and guides patients to go to the right room.
FRAM 4 Example 4.3	*To go to blood sampling room* On arrival to the blood clinic, the patient receives a queue number. The queue number will come up on a screen in the waiting room and 'tell' the patient to which blood sampling room they have to go to for the blood sampling	All patients go to the blood sampling room as indicated on the screen	Some patients get their blood tested very often. These patients have a preferred phlebotomist. Regardless the room number on the screen, the patients go to the blood sampling room where the preferred person is

All the examples in table 5 have in common that not all the people involved in the actual work situation knew the adjustments. For example, the health care professionals at the hospital unit in FRAM 2 did not know that the GP normally only read the heading of the CT-scan report. They expected the GP to read the full report. In FRAM 3 the six physicians did not know that their colleagues had individual ways of categorizing '*Urgent*'. In FRAM 4 the manager did not know that the receptionist in the blood clinic had to help certain groups of patients to find their way to the right blood sampling room.

6.2. Modelling everyday work

The output of step 1 in a FRAM analysis is a model of everyday work [Hollnagel, 2012a]. In this study, the description of everyday work is modelled with the FMV (FRAM Model Visualiser). The model for each of the four FRAMs visualize how the functions in the work situation depend on each other and interrelate.

The four FRAM models are shown in figure 5, 6, 7, and 8. In the figures, a function is visualized by a hexagon with an aspect in each of the six corners. The different aspects are Input (I), Output (O), Resource (R), Control (C), Precondition (P) and Time (T). The aspects are described in detail in appendix B.

To limit the size of a FRAM model only the function(s) in focus is described with more than one aspect. The functions are named *foreground functions*. Functions described only by an input or an output are visualized by a quadrant in the model. These functions are not in focus. The functions are named background functions.

The hexagons in a FRAM model can be coloured to support the feedback to the health care professionals.

6.2.1. FRAM 1 Ward Rounds

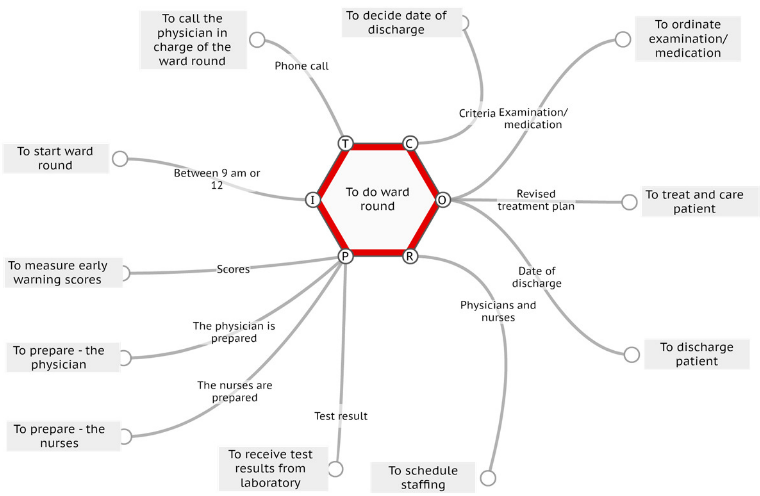
Figure 5 shows the model of FRAM 3 Ward Rounds. The FRAM 3 model is very simple. Only one function was needed to describe how ward rounds normally are done. This function is the foreground function and is coloured red in figure 5.

The FRAM 1 model describes how a ward round is normally started and conducted:

The ward round starts when the physician and the nurses are prepared and have found each other. Normally this is between 9 am and 12. When the ward round starts at 12, the patient cannot be discharged same day due to lack of time to carry out the discharge function. During the ward round the physician in charge is often interrupted by phone calls. This also delays the finish of the ward round.

The physician in charge of the ward round sets the date of discharge in cooperation with the nurses. Each physician has his/her own way of setting the date; some do not set a date at all and the patient is discharged when ready.

Figure 5 The FRAM 1 model



6.2.2. FRAM 2 Spine Fracture

Figure 6 shows the model of FRAM 2 Spine Centre. Only one function '*To read test result'* is described by all six aspects.

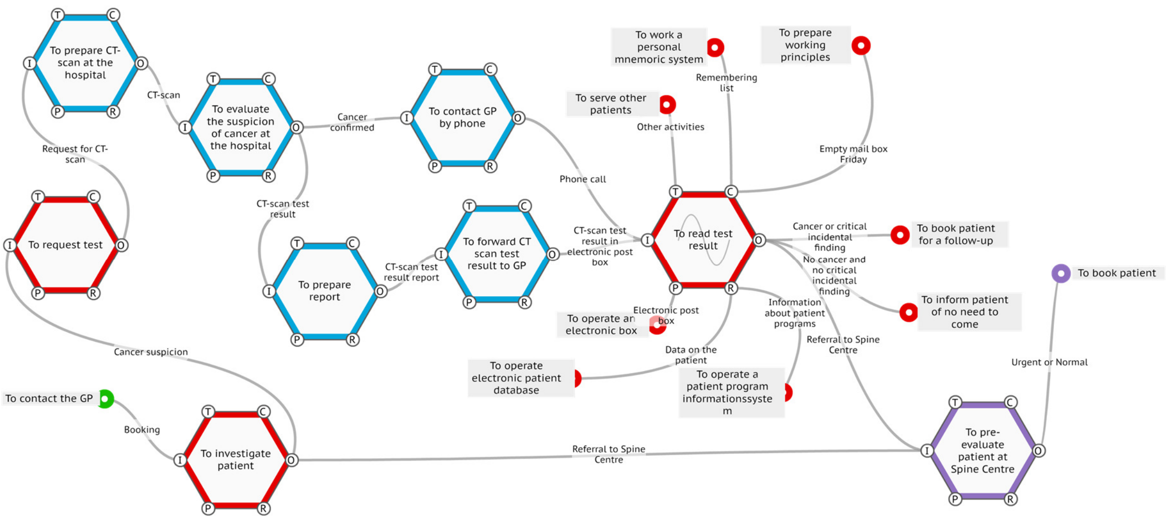
The FRAM 2 model describes everyday work as follows:

A patient in pain contacts his GP. The GP receives and evaluates the patient. The GP suspects cancer and decides to refer the patient to the hospital for a CT scan. The CT scan is prepared and evaluated by the hospital. The CT scan confirms no cancer but also an unstable spine fracture. The CT scan test result is forwarded only to the GP and the hospital do not inform the patient according to normal procedure. According to normal procedure 'No cancer' *is highlighted in the heading of the result and the critical incidental finding of a spine fracture is only described in the text of the test result. The GP receives the test result and reads only the heading (normal procedure) and does not notice the incidental finding of a spine fracture). The GP informs the patient that the CT scan showed no cancer and that the patient does not need a follow-up meeting.*

After some time the patient comes back to the GP. The patient is still in pain. The GP receives and evaluates the patient. The GP decides to refer the patient to the Spine Centre for general evaluation of the patients back. The physician at the Spin Centre pre-evaluates according to normal procedure and looks at the GP's referral and the age of the patient. The patient is categorized 'Normal' and is booked for an examination. During the examination, the CT scan is assessed due to normal procedure and the unstable spine fracture unveiled by the health care professionals.

The description of everyday work shows that the incidental finding of an unstable spine fracture will not be noticed in the system. It was unveiled because the patient kept coming back to the GP and was referred to the Spine Centre.

Figure 6 The FRAM 2 model



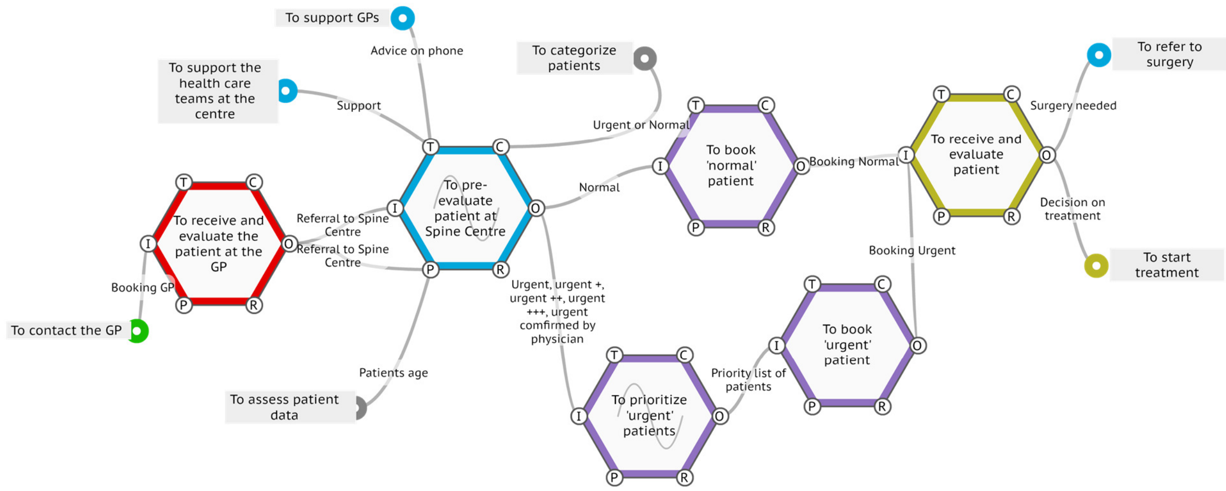
6.2.3. FRAM 3 Pre-evaluation of patients with back pain

Figure 7 shows the model of FRAM 3 Pre-evaluation of patients with back pain. Blue coloured hexagons/quadrants represent the function carried out by the physicians at the Spine Centre, red coloured are functions at the General Practitioner (GP), green coloured functions are the patient, the Physiotherapists at the Spine Centre do yellow coloured and the medical secretary at the Spine Centre does purple coloured functions. Two functions '*To assess patient data*' and '*To categorize patients*' are gray coloured to indicate that these functions are organisational. All other functions are human.

The FRAM 2 model describes everyday work as follows:

A patient in pain contacts his GP. The GP receives and evaluates the patient. The GP refers the patient to the Spine Centre for general evaluation of the patients back. The physician at the Spine Centre pre-evaluates and categorizes the patient 'Normal' or 'Urgent'. Depending on the physician the patient can be sub-categorized in 'Urgent', ' Urgent +', 'Urgent ++', 'Urgent +++' or 'Urgent with the verbal confirmation by the physician that the patient is urgent'. The medical secretary receives the different categorizations of urgency and makes the final prioritization. Normally a patient categorized as 'Urgent +' will be given a higher priority by the secretaries than an 'Urgent', even though this is not the case.

Figure 7 The FRAM 3 model



The description of everyday work shows that each the physician has their own system for making sub-categories of the category 'Urgent'. This variation is unknown to the other physicians and only known to the medical secretaries. The consequence is that the secretaries do the final priority and book the patients in the best way they can.

6.2.4. FRAM 4 Blood Sampling

A blood clinic changed a workflow to increase productivity. They have used the production philosophy LEAN to focus on waste and flow. Before LEANing the workflow, the patients were registered by arrival at the reception of the blood clinic in an electronic queueing system. The phlebotomist taking the blood sample went to the waiting room and accompanied the next patient to the blood sampling room, where the phlebotomist took the blood sample.

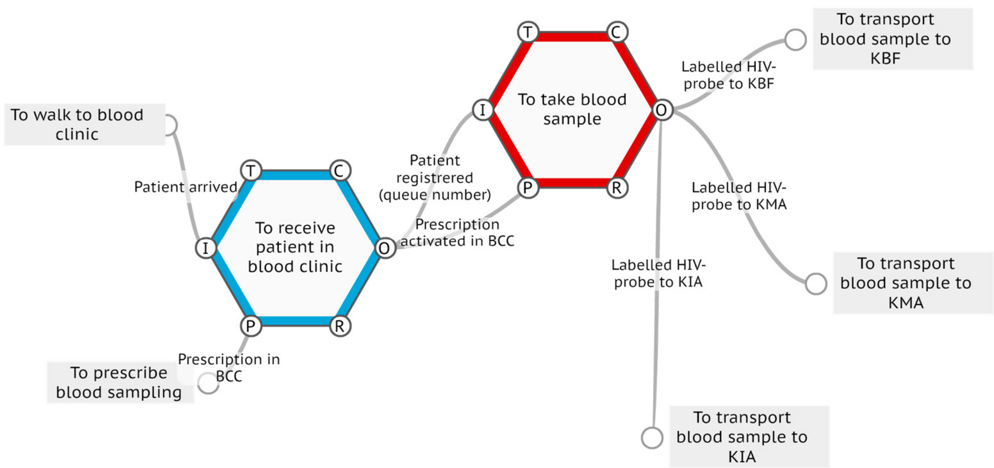
After LEANing the workflow, the patient gets a queueing number at arrival at the reception and is instructed by a big screen in the waiting room to walk to a specific blood sampling room. The patient is waiting outside on a chair in front of the blood sampling room, until invited into the room by the phlebotomist. The goal of the LEAN project was to increase productivity by avoiding the phlebotomist use time to fetch the patient in the waiting room.

Through an interview with the manager of the blood clinic, it was possible to describe and model how management imagined the work done from their perspective (work-as-imagined):

On arrival to the blood clinic, the patient receives a queueing number. The queueing number will come up on a screen in the waiting room and 'tell' the patient to go to a chair in front of the blood sampling room (room number). The patient waits in front of the room, until the phlebotomist invites the patient into the room.

Figure 8 shows the model of WAI. The two coloured hexagons, representing '*To receive patient in blood clinic*' (blue) and '*To take blood sample*' (red) are needed to understand why the clinic did not achieve the expected increase in productivity by implementing the LEANed workflow. In the model, these two functions are the foreground functions. The receptionist does the blue coloured function and the phlebotomist does the red coloured function.

Figure 8 The FRAM 4 model WAI



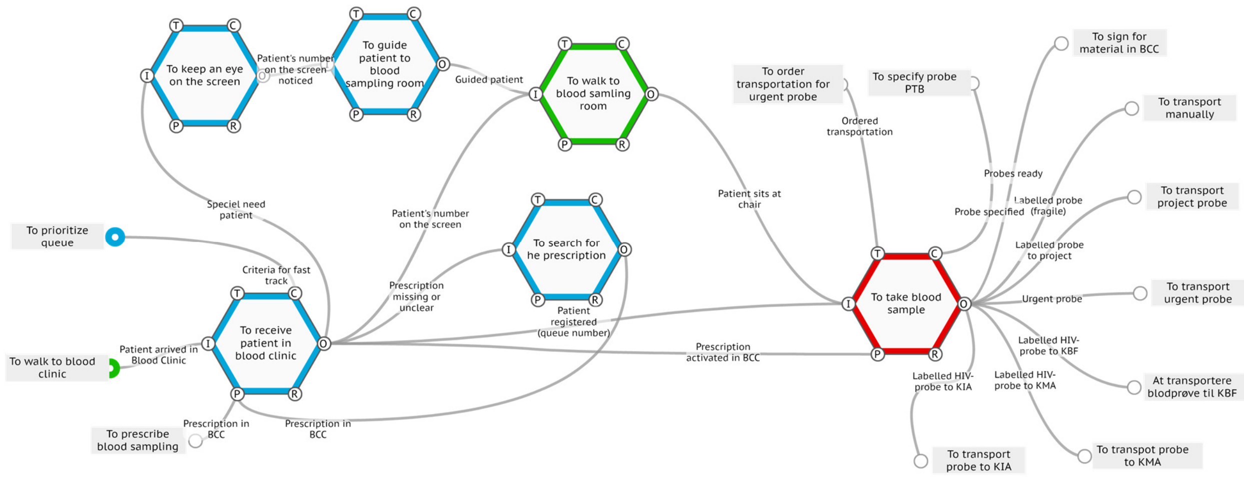
The interviews with the health care professionals gave a different picture. Figure 9 shows how the work is actually done (WAD):

The patient arrives at the reception of the blood clinic and gets a queueing number. For some patients the receptionist cannot find the required prescription and uses time to find the needed prescription to avoid sending the patient home empty-handed.

The patient watches a big screen in the waiting room. When the queueing number comes up on the screen the patient walks to the blood sampling room, as instructed on the screen. Some patients prefer phlebotomist A rather than other phlebotomists. Despite the room number on the screen, they seat themselves in front of the room where phlebotomist A is taking the blood samples. When phlebotomist A sees a well-known patient, normally the patient is accepted and invited into the room. The phlebotomist in the blood sampling room to which the patient was called, would normally search for the patient, before taking the next patient in.

Some patients do not have the cognitive ability for complying with the new system. Normally, the receptionist is able to spot these patients. The receptionist keeps an eye on the screen and assists the patients when their queueing number comes up on the screen. The receptionist runs a personal mnemonic system to remember which patients to assist.

Figure 9 The FRAM 4 model WAI



7. Analysis of data

Chapter 7 describes the result of analysing the data collected through semi-structured interviews of the health care people actually doing the work.

Chapter 7.1 explains the adjustments identified in the four FRAM analyses (described in table 5 in chapter 6.1) by using the ETTO principle. The ETTO principle is exemplified by rules related to work, to individuals or to the organisation. [Hollnagel, 2009]

This study uses mainly the work related ETTO rules to explain identified adjustments. Chapter 7.2 describes how the identified adjustments in the four FRAMs result in performance variability and how the variability of functions can couple and propagate into an unexpected and unwanted outcome for the patient (functional resonance).

The description of functional resonance in a FRAM model is the basis for identifying opportunities for improving patient safety in everyday work. Chapter 7.3 describes how management and health care professionals used the description in the four FRAMs to identify the opportunities. The last chapter 7.4 describes common patterns in adjustments of everyday work, found in the bout 30 FRAM models prepared from March 2012 to February 2016.

7.1. ETTOing

The balancing of efficiency and thoroughness in everyday work describes how people adjust the way they do the work to match the requirements of the actual situation. A set of ETTO rules commonly found in practice at workplaces can explain the identified adjustments. The rules do not constitute causes of behaviour, but behaviour can be described '*as if*' an ETTO rule is followed.

In the chapters 7.1.1 to 7.1.4, the examples of adjustments identified in the four FRAMs are related to one or more of the 17 work related ETTO rules, listed in Appendix E.

7.1.1. FRAM 1 Ward Rounds

In example 1.1, the ward round starts when the nurses and the physician in charge are prepared and they have found each other, see table 6.

The behaviour of the team is social. The nurses and the physician in charge wait for each other to be prepared. While waiting they use the time to do other things, e.g. to be effective. Before starting the ward round, they therefore have to find each other..

Table 6 Example 1.1

Example no.	Function	Work-as-imagined	Work-as-done
Example 1.1 FRAM 1	*To do ward round* The ward round is a cooperation between the physician in charge and the nurses at the ward.	The ward round starts when the nurses and the physician in charge are prepared.	The ward round starts when the nurses and the physician in charge are prepared and they have found each other, normally somewhere between 9 am and 12 noon.

The behaviour corresponds to two different ETTO rules:

- ✓ '*We always do it in this way*' – the team has done the ward rounds in this way for a long time. They feel that this is an effective way of doing it, because they can use the waiting time to do other things
- ✓ '*It normally works*' – the team has experienced that the way they do the ward rounds normally works. This eliminates the effort needed to consider the situation in detail in order to find a different way to do the ward rounds

In example 1.2, criteria were not defined for setting the date and time of discharge of the patients and each of the physicians in charge of a specific ward round had their own way of doing it, see table 7.

Table 7 Example 1.2

Example no.	Function	Work-as-imagined	Work-as-done
Example 1.2 FRAM 1	*To do ward round* Different physicians are in charge of the ward rounds during the week	Common criteria for setting the date and time of discharge are defined	Common criteria are not defined and the physicians use their own criteria for setting the date and time of discharge

The behaviour corresponds to three different ETTO rules:

- '*Doing it in this way is much quicker*' – in the absence of an agreed way of setting the date and time of discharge, each physician in charge of a specific ward round has established a routine on his/her own that is believed to be efficient and safe
- '*I (we) always do it in this way*' – each physician has found a way of setting the date and time of discharge that is believed to work effectively and safe. There is no need to use time to find a new way
- '*It normally works*' – each physician has experienced that the way they set the date and time of discharge normally works. This eliminates the effort needed to consider a new way of doing it

7.1.2. FRAM 2 Spine Fracture

In example 2.1, the physicians normally assess the GP's written referral and the age of the patient during pre-evaluation and not the patient's test results, see table 8.

Table 8 Example 2.1

Example no.	Function	Work-as-imagined	Work-as-done
Example 2.1 FRAM 2	*To pre-evaluate patient at Spine Centre* Six different physicians prepare the pre-evaluation at the Spine centre.	The physician assesses all the patient's test results during pre-evaluation	The physician only assesses the General Practitioner's (GP's) written referral and the age of the patient. This is normal procedure for all six physicians

The behaviour corresponds to three different ETTO rules:

- '*It has been checked earlier by someone else*' – the physician does not need to assess the patients' test results, because it has been checked earlier by the patient's GP. The physician can skip the assessment of the test results during the pre-evaluation. He/she saves time by doing so and is efficient in the pre-evaluation

- ‘*It will be checked later by someone else’* – the physician knows that the physiotherapist at the first contact with the patient, assesses the test results with the patient. The physician can skip the assessment of the test results during the pre-evaluation and be efficient in the pre-evaluation
- ‘*It normally works*’ – the physician does not need to consider the situation in detail by assessing the test results in order to find out what to do (prioritize the patient as ‘normal’ or ‘urgent’), because it normally works to limit the pre-evaluation to the GP’s written referral and the patient’s age

In example 2.2, the hospital unit, preparing the CT-scan, uses the heading of the test result report to interpret the main finding related to the suspicion of cancer. Incidental findings are not mentioned in the heading, only in the text below. This is normal procedure at the hospital unit, see table 9.

Table 9 Example 2.2

Example no.	Function	Work-as-imagined	Work-as-done
Example 2.2 FRAM 2	*To prepare report* A hospital unit prepares and assesses CT-scan to confirm suspicion of cancer. A report with the test result is forwarded to the patients General Practitioner (GP)	The GP expects that the heading of the test result includes all findings, both the main finding related to the suspicion of cancer and incidental findings that need action to be taken	The heading includes only the main finding related to the suspicion of cancer and not incidental findings. This is normal procedure at the hospital unit.

The behaviour corresponds to two different ETTO rules:

- ‘*It will be checked later by someone else’* – the hospital unit has the habit of highlighting the main result in the heading. Incidental findings, even those that need action from the GP, are not highlighted in the heading Incidental findings are only mentioned in the text of the report. The hospital unit expects the GP to read both heading and full text of the test result report
- ‘*It normally works’* – the hospital unit has established an effective routine of reporting test results that normally works and results in the wanted outcome for the patient

In example 2.3, the GP normally reads the headings and not the full text in the test report, see table 10.

Table 10 Example 2.3

Example no.	**Function**	**Work-as-imagined**	**Work-as-done**
Example 2.3 FRAM 2	*To read test result* The General Practitioner (GP) assessment of a CT-scan report (suspicion of cancer)	The hospital unit preparing the CT scan expects the GP to read the full text of the test result report	The GP only reads the heading of the test result. This is normal procedure.

The behaviour corresponds to two different ETTO rules:

- '*It has been checked earlier by someone else*' – the GP is not reading the full text because he/she expects that the unit at the hospital, reporting the test result, have assessed the findings thoroughly and used the heading to indicate which findings that need action. By only reading the heading the GP saves time for other patients
- '*It normally works*' – the GP has established an effective routine of assessing test results that normally works and results in the wanted outcome for the patient, saving time for other patients

7.1.3. FRAM 3 Pre-evaluation of patients with back pain

In example 3.1, the six physicians, pre-evaluating the patients at the Spine Centre, have expanded the category '*Urgent*' each in their individual way, see table 11.

The written procedure describes two possible categories – '*Normal*' and '*Urgent*'. This categorization of the patients, does not fulfil the need of the six physicians, because some urgent patients are categorized as more urgent than other urgent patients. There has been no agreement on expanding the category '*Urgent*' and each of the six physicians has established their own way to ensure the correct priority of the patients, e.g. that the most urgent patients get the highest priority.

Table 11 Example 3.1

Example no.	Function	Work-as-imagined	Work-as-done
Example 3.1 FRAM 3	*To pre-evaluate patient at Spine Centre* The pre-evaluation is prepared by six physicians and the result of the pre-evaluation is to categorize the patients	The six physicians all work according to the written procedure, using two categories '*Urgent*' or '*Normal*'	The six physicians have expanded the category '*Urgent*'. Some follow the written procedure. Some use '*Urgent +*', '*Urgent ++*', or '*Urgent +++*'. Some inform the medical secretary verbally that a patient is more urgent than other patients categorized as '*Urgent*'

The behaviour corresponds to the ETTO rule:

- ✓ '*Doing it in this way is much quicker or resource efficient*' – by expanding the category 'Urgent', it is believed that the patients with the most urgent needs get the highest priority, even though it does not comply to the written procedure

In example 3.2, because of the expansion of the category '*Urgent*', the urgent patients are not booked in chronological order, see table 12.

Table 12 Example 3.2

Example no.	Function	Work-as-imagined	Work-as-done
FRAM 3 Example 3.2	*To book patient* The medical secretaries book time for the patients according to the result of the pre-evaluation	The patient in the category '*Urgent'* are booked in chronological order	A patient categorized '*Urgent*' will normally be overtaken by patients categorized as '*Urgent +*', '*Urgent ++*', '*Urgent +++*' or if the physician informs the medical secretary verbally that a patient is more urgent than all other patients categorized as '*Urgent*' are.

The medical secretary accepts that patients categorized as '*Urgent*' are overtaken by patients categorized as '*Urgent +*', '*Urgent ++*', '*Urgent +++*' or verbally said to be urgent by a physician.

The behaviour corresponds to the ETTO rule:

- ✓ '*It is really not important*' – despite the different ways of categorizing urgent, all the patients are still given a high priority compared to the patients categorized as '*Normal*' and therefore the medical secretaries have no need to change the routine of the six physicians

7.1.4. FRAM 4 Blood Sampling

In example 4.1, the receptionist uses time to find the prescription to take a blood sample, see table 13.

Table 13 Example 4.1

Example no.	**Function**	**Work-as-imagined**	**Work-as-done**
FRAM 4 Example 4.1	*To find prescription* A precondition for taking a blood sample is a prescription, prepared by a physician in an electronic system	The receptionist in the blood clinic can always find a prescription in the electronic system when a patient arrives to the clinic	Every day prescriptions are missing. The receptionist uses time to find a missing prescription to avoid sending the patient home empty-handed

Normally the ETTO rules exemplify how to gain time by being less thorough. In this example, the receptionist decides to be thorough instead of efficient to avoid sending the patient home empty-handed. The behaviour results in the use of more time than imagined. The behaviour on the other hand ensures efficiency from the perspective of the patient. The patient does not need to revisit the blood clinic.

In example 4.2, the receptionist uses time to help certain groups of patients find their way to the right blood sampling room, shown on the screen in the waiting room, see table 14.

As in example 4.1, the receptionist in example 4.2, decides to use time to ensure the functioning of the system, e.g. to be thorough.

Table 14 Example 4.2

Example no.	Function	Work-as-imagined	Work-as-done
FRAM 4 Example 4.2	*To go to blood sampling room* On arrival to the blood clinic, the patient receives a queue number. The queue number will come up on a screen in the waiting room and 'tell' the patient which blood sampling room they have to go to for the blood sampling.	All patients can interpret the information on the screen and find their way to the blood sampling room	Certain groups of patients cannot use the information on the screen. The receptionist therefore keeps an eye on the screen, reminds, and guides patients to the right room.

The behaviour results in the use of more time than imagined. On the other hand, the behaviour ensures efficiency from the perspective of the patient. The patient is assisted to get to the right blood sampling room.

In example 4.3, the patient goes to a different blood sampling room than indicated on the screen in the waiting room, see table 15.

Table 15 Example 4.3

Example no.	Function	Work-as-imagined	Work-as-done
FRAM 4 Example 4.3	*To go to blood sampling room* On arrival to the blood clinic, the patient receives a queue number. The queue number will come up on a screen in the waiting room and 'tell' the patient which blood sampling room they have to go to for the blood sampling.	All patients go to the blood sampling room as indicated on the screen	Some patients get their blood tested very often. These patients have a preferred phlebotomist. Regardless of the room number indicated on the screen, the patients go to the blood sampling room where the preferred person is

The phlebotomist in the blood sampling room where the patient was supposed to go does not find the patient waiting in front of the room. He/she is using time to find the patient instead of taking the next patient in the queue.

The phlebotomist decides to be thorough instead of efficient to ensure the functioning of the system and avoiding the patient missing the appointment. Like the previous two examples 4.1.and 4.2, the behaviour of the phlebotomist results in the use of more time than imagined.

The behaviour on the other hand ensures efficiency from the perspective of the patient that does not need to revisit the blood clinic because of missing the appointment.

The phlebotomist that accepts the well-known patient even though the patient went to the 'wrong' blood sampling room, is related to the ETTO rule '*If you won't say anything, I won't either*'. In this situation, the phlebotomist 'bend the rules' in order to make life easier for the patient. This kind of trade-off involves more than one person and is said to be social instead of individual.

7.1.5. Organisational ETTOing

As mentioned in the introduction to chapter 7, the ETTO principle can be exemplified by rules related to work, to individuals or to the organisation. Example 4.1, 4.2 and 4.3 can also be described '*as if*' the people followed an organisational ETTO rule, called the 'double-bind' [Hollnagel, 2009]. 'Double-bind' is a situation where a person receives different and contradictory messages. If for example the blood clinic has an explicit policy that states '*Patient first*' and an implicit policy to be efficient, the health care professionals in the three examples behave '*as if*' they emphasize the explicit policy '*Patient first*' over the implicit policy to be efficient.

7.1.6. TETOing

Hollnagel (2009) states that efficiency in the present presupposes thoroughness in the past and that thoroughness in the present is necessary for the efficiency in the future. The latter is known as the TETO principle (Thoroughness-Efficiency-Trade-Off) [Hollnagel, 2009]. When people actually doing the work emphasize thoroughness over efficiency, like examples 4.1, 4.2 and 4.3, the people behave '*as if*' the people followed the TETO principle to ensure that the new LEANed workflow can be efficient in the future.

7.1.7. Summary ETTOing

The ETTO rules can explain and predict the behaviour of people when they adjust everyday work to the actual situation.

The explanation of the adjustments in this study represents seven of the seventeen ETTO rules. The two most common ETTO rules in the examples are '*It normally works*' and '*It has been checked earlier by someone else*'. People will use well-established routine that has been shown to be safe and effective to gain time to handle unexpected situations, behaving '*as if*' they followed the ETTO rule '*It normally works*'. People also trust that their colleagues have been thorough in their work (upstream functions) so that they in the actual situation, can be effective. They behave '*as if*' they followed the ETTO rule '*It has been checked earlier by someone else*'.

Adjustments of everyday work normally ensure the safe and effective functioning of the system, but can also lead to an unwanted and unexpected outcome. Normally the performance variability of a function in itself cannot destabilize the situation. Sometimes the performance variability of several functions can combine (couple) in a manner resulting in an unusually large variability and destabilize the situation. The phenomenon is called '*functional resonance*' and the next chapter 7.2, describes how functional resonance emerges in the four FRAM models.

7.2. Functional resonance

The Trade-Off between efficiency and thoroughness is affected by the conditions and is not '*a built-in, fixed ratio*' [Hollnagel, 2009]. ETTOing can result in performance variability of functions. The performance variability can propagate through the system. Sometimes the variability is dampened and sometimes it becomes unusually large, e.g. resonance. The resonance is functional, not stochastic because the ETTO principle makes it possible to predict the behaviour of people and therefore the potential resonance in a workflow. The behaviour is not random and represents a certain regularity. [Hollnagel, 2012a] [Akselsson, 2014]

In the chapters 7.2.1 to 7.2.4 the four FRAM models described in chapter 6.2, are used to visualize how the performance variability of a function can become unusually large, when propagating through the system.

Using the FRAM model to predict functional resonance by visualizing how the functions can couple under given conditions is called an instantiation. In a given model, many instantiations are possible. Each instantiation represents couplings between upstream and downstream functions at a given time or for given conditions.

7.2.1. FRAM 1 Ward Rounds

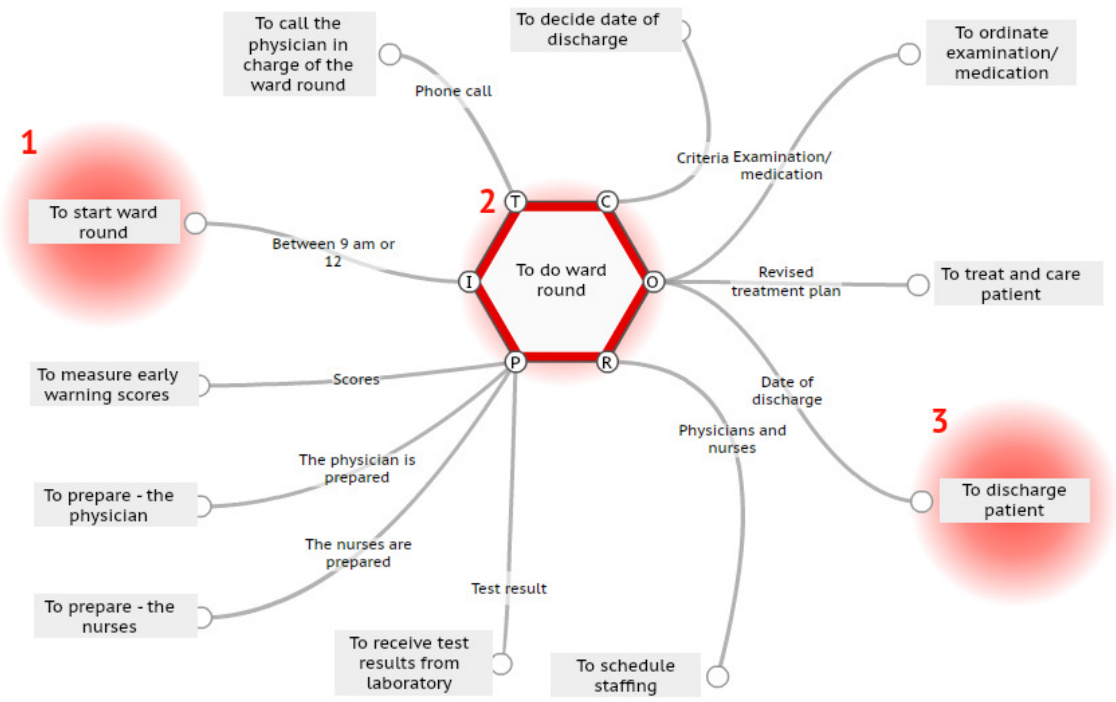
The purpose of the ward round is to set the right date and time to discharge the patients. If a patient is discharged too early, there is a risk for readmission. If the patient is discharged too late, there is a risk of infections and pressure ulcer. A late discharge is also putting a pressure on the ward's capacity, finance and waiting list.

The data for FRAM 1 showed that work-as-done resulted in performance variability of the function '*To start ward round*' (marked with a red number '1' in figure 10). The output of the function, e.g. the start signal of the function '*To do ward round*' (marked with a red number '2' in figure 10) would vary between 9 am and 12 midday. Two conditions had to be fulfilled prior to the start of the ward round: the physician had to be prepared and the nurses had to be prepared. While waiting for each other to be prepared, each of them used the time to do other things, but also used time to find each other. When the ward round started at 12 midday the function '*To discharge patient*' (marked with a red number '3' in figure 10) did not have time enough to ensure a safe discharge of the patient and the patient had to wait another 24 hours before being discharged.

The function 'To do ward round' is not able to gain the lost time of a late start, e.g. to dampen the variability and the result is that the discharge can happen later than the 'right' time for the patient. The patient risks infections and/or pressure ulcer – an unwanted patient outcome. This is an example of functional resonance in FRAM 1.

The instantiation described in this chapter shows how time is lost in everyday work with a possible extension of a patients stay in the ward and an increasing risk of infections or pressure ulcer.

Figure 10 Instantiation of FRAM 1 model Ward Rounds



Chapter 7.3.1 describes the opportunities for improvement proposed by the health care professionals involved in the FRAM 1 analysis.

7.2.2. FRAM 2 Spine Fracture

In the FRAM 2 the instantiation covers the time-frame of the patient safety incident and represents the couplings that existed at the time:

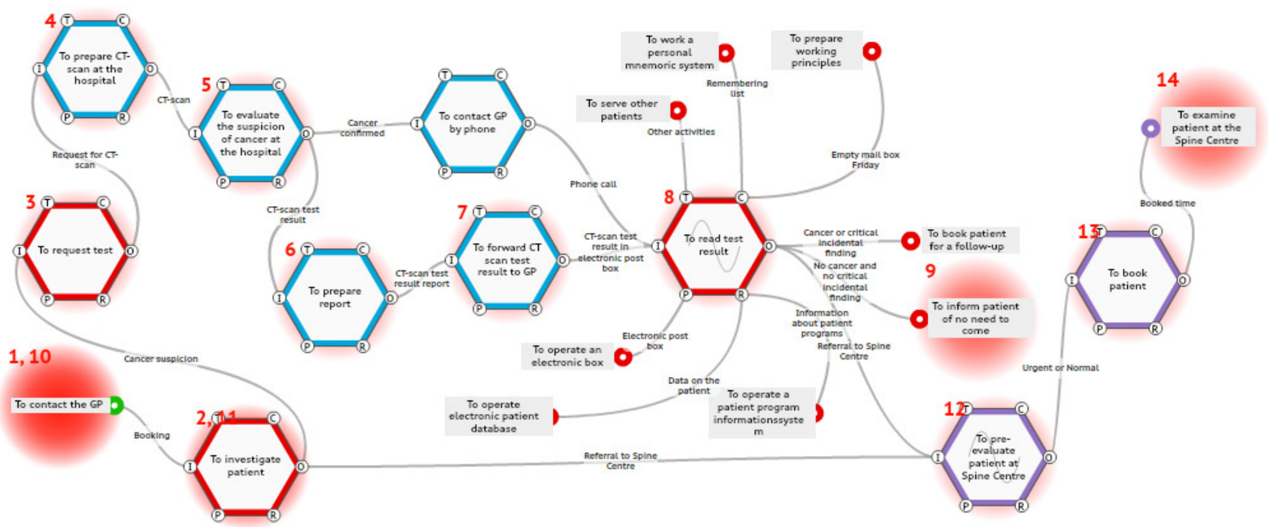
Because of back pain, the patient contacts his/her General Practitioner (GP) (function marked with a red '1' in figure 11). The GP investigate the patient (function marked with a red '2' in figure 11) and decides to request a CT-scan to confirm cancer or no cancer (function marked with a red '3' in figure 11). The patient goes to the hospital where a CT-scan is prepared (function marked with a reed '4' in figure 11). The physician at the hospital unit evaluates the CT-scan (function marked with a red '5' in figure 11) and finds no cancer.

The physician prepares a test result report (function marked with a red '6' in figure 11). As normally, the main finding of no cancer is mentioned in the heading and the incidental finding of an unstable spinal fracture is only mentioned in the text under the heading. The physician forwards the report to the patient's GP (function marked with a red '7' in figure 11). As normally, the GP reads only the heading of the report and does not notice the incidental finding of an unstable spinal fracture (function marked with a red '8' in figure 11). The GP expects that incidental findings that need his actions are mentioned in the heading and by only reading the headings, the GP saves time for other patients. The GP informs the patient that the CT-scan confirmed no cancer and that the patient need not to come to the health centre (function marked with a red '9' in figure 11).

After some time and still in pain, the patient revisits his/her GP (function marked with a red '10' in figure 11). The GP investigates the patient and decides to refer the patient to the regional Spine Centre for a general evaluation of the patient's back (function marked with a red '11' in figure 11). At the Spine Centre and as normally, a physician pre-evaluates the patient by looking through the referral of the GP in combination with the age of the patient (function marked with a red '12' in figure 11). The patient is categorized as 'Normal' and the medical secretary books a time according to this category (function marked with a red '13' in figure 11). During the first examination in the Spine Centre, the information on the patient is reviewed together with the patient and the incidental finding is unveiled (function marked with a red '14' in figure 11). Immediately, the patient is referred to surgery.

The instantiation of the FRAM 2 model explains how the patient safety incident could happen but not how it happened. The instantiation points out that the performance variability of the function '*To prepare report*' (marked with a red '6' in figure 11) is increased in the function '*To read test result*' (marked with a red '8' in figure 11). None of the following functions in the actual patient pathway are able to 'dampen' the variability by unveiling the incidental finding of an unstable spine fracture (marked with red numbers from 9 to 13 in figure 11). The function '*To examine patient at the Spine Centre'* (marked with a red '14' in figure 11) is unveiling the incidental finding. The outcome for the patient was more than five months in pain.

Figure 11 Instantiation of FRAM 2 Spine fracture



The instantiation is the basis for management and health care professionals to identify opportunities for improving patient safety in everyday work. Chapter 7.3.2 describes patient interventions proposed by the health care professionals involved in the FRAM 2 analysis.

7.2.3. FRAM 3 Pre-evaluation of patients with back pain

The purpose of the pre-evaluation of patients at the Spine Centre is to ensure that patients with the most urgent need are offered an examination before patients with less urgent need. The written procedure gives the six physicians two categories to use in the pre-evaluation: '*Normal*' and '*Urgent*'. In the category '*Urgent*' the patients were supposed to be prioritized in chronological order.

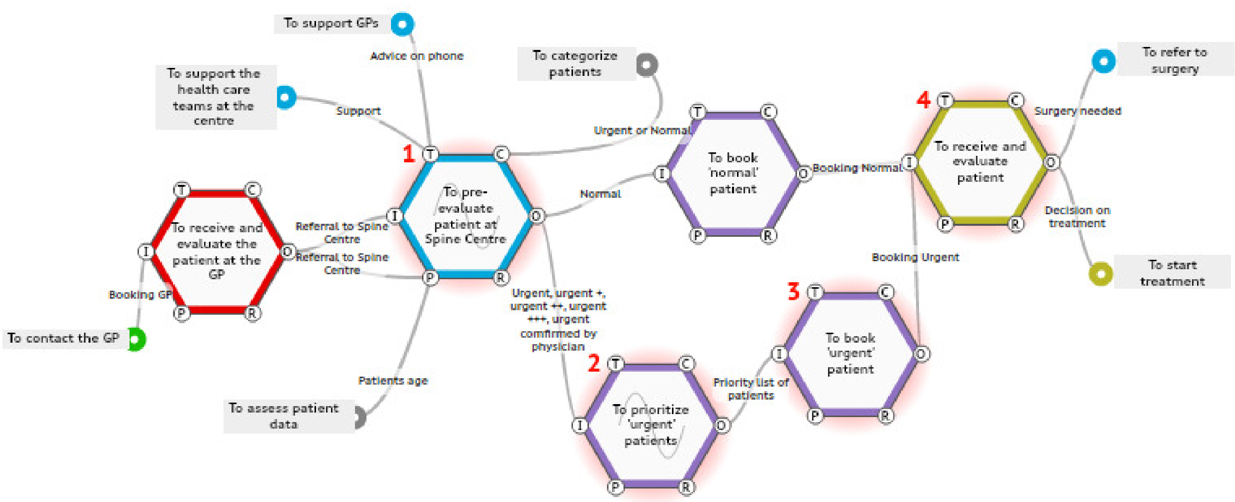
The data for FRAM 3 showed that for the function '*To pre-evaluate patient at Spine Centre*' (marked with red '1' in figure 12) work-as-done resulted in multiple ways of categorizing the urgent patients, because the six physicians had different ways of defining the category '*Urgent*':

- ✓ '*Urgent*'
- ✓ '*Urgent +*'
- ✓ '*Urgent ++*'
- ✓ '*Urgent +++*'
- ✓ '*Urgent + physician verbally informing the medical secretary of the urgency*'

The consequence is, that the medical secretary had to decide if '*Urgent* +' is more urgent than '*Urgent*' or '*Urgent* ++' is more urgent than '*Urgent + physician verbally informing the medical secretary of the urgency'*, not knowing the right answer (function marked with a red '2'). The priority by the medical secretary could result in an unexpected resonance, where a patient with very urgent need is given a lower priority (function marked with red '3' in figure 12). The longer waiting time could result in an aggravation of the situation for the patient and the chance of cure and recovery.

In this instantiation, all of the health care professionals in the actual workflow is trying to do a good job, but they do not realize the consequence of their behaviour on the patient's outcome.

Figure 12 Instantiation of FRAM 3 Pre-evaluation of patients with back pain



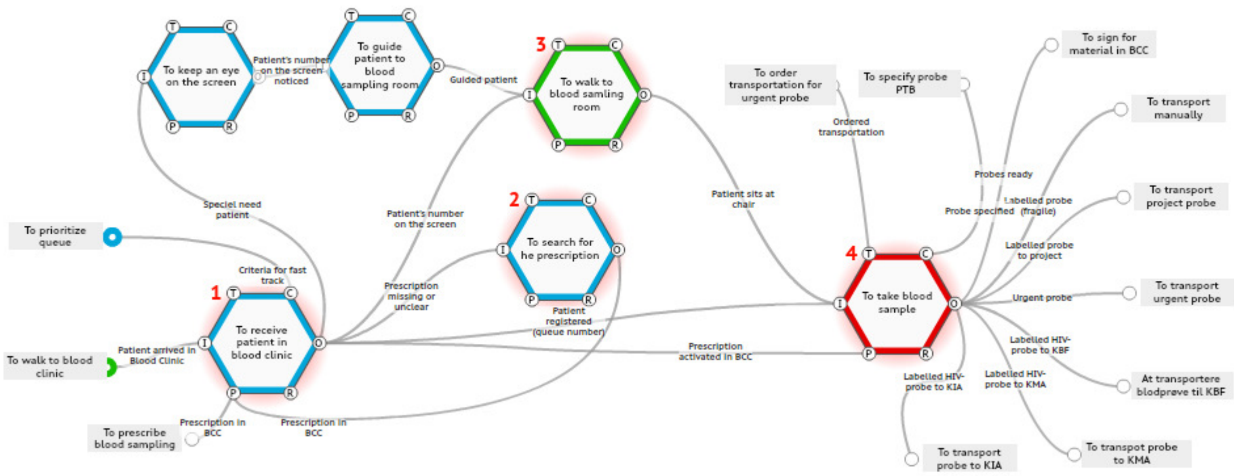
The instantiation is the basis for management and health care professionals to understand how the performance variability of the pre-evaluation can have unexpected and unacceptable outcome for the patient. Chapter 7.3.3 describes the patient safety interventions proposed by the health care professionals involved in the FRAM 3 analysis.

7.2.4. FRAM 4 Blood Sampling

The purpose of FRAM 4 was to explain why the blood clinic did not achieve the expected time saving by changing the workflow. Previously, the phlebotomist walked from the blood sampling room to get the patient in the waiting room and followed the patient back to the blood sampling room. After the change, the patient has to find his/her own way to the right blood sampling room, where the phlebotomist is waiting for the patient to arrive. If the phlebotomist is delayed, the patient has to wait at a chair outside the blood sampling room.

The first instantiation of the FRAM 4 model shows that the receptionist uses time to find the prescription of the patients (loop of the function marked with a reed '1' and '2' in figure 13). If the receptionist finds the prescription the patient gets a queue number and goes to the blood sampling room when 'called' on the screen and gets the blood sample taken (the functions marked with a red '3' and '4' in figure 13).

Figure 13 Instantiation 1 of FRAM 4 Blood sampling



If the receptionist does not succeed in finding the prescription, the patient has to go home empty-handed and the receptionist has to rebook the patient and use time the day after to find the prescription.

The time wasted, may have been used for other more valuable tasks than looking for a missing prescription.

When using more time on one patient, other patients have to wait to be registered; consequently, the queue will grow and the receptionist will be under increasing work pressure. The need to be thorough makes the system less efficient and increases the waiting time, e.g. an unwanted result (resonance).

The situation was unknown to the management, but known to the receptionist.

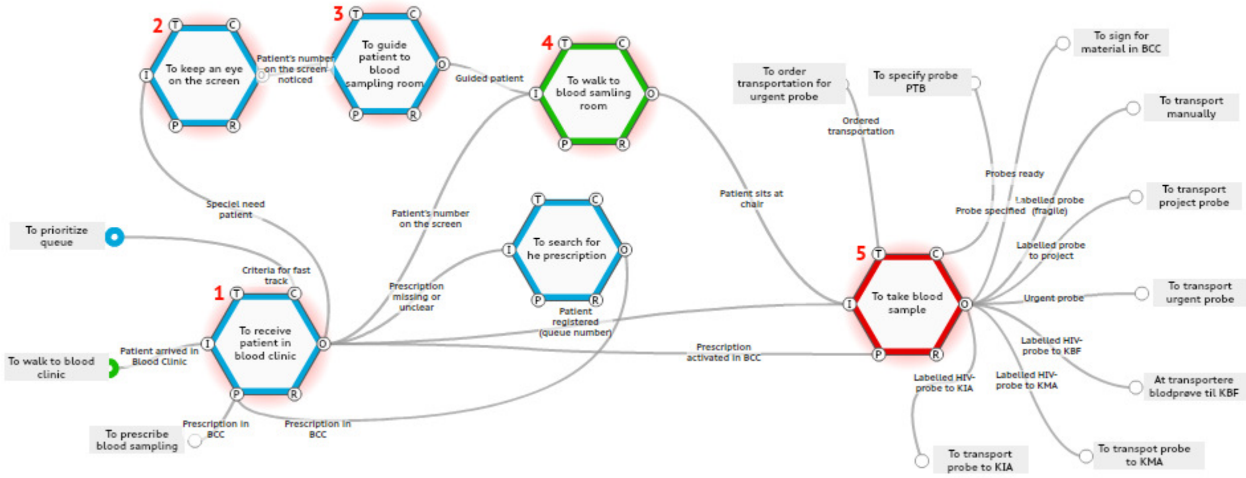
The second instantiation of the FRAM 4 model, see figure 14, shows the situation where the receptionist spots a patient not capable of using the information on the screen. The receptionist keeps an eye on the screen, reminds and guides the patient to the right blood sampling room. To make the system work, the receptionist must be thorough. The receptionist must be able to spot this type of patient among all the other patients. The performance depends on the experience of the receptionist. There is a risk that unexperienced people do not spot all of these patients.

The electronic registration system does not allow the possibility of marking the queued patients and the receptionist depends on an individual mnemonic system, such as Post-It on the office table or computer screen. When busy or being disturbed, the receptionist can miss the reminder to guide the patient to the right blood sampling room. The situation can end in resonance, where the patient waits longer. In worst case, this wait can be to the end of the working day.

On the other hand, when the phlebotomist does not find the patient outside the blood sampling room, he/she can go and search for the patient. If the patient is found in the waiting room, the variability is dampened. If the phlebotomist decides to call for the next patient, the variability will increase (increasing waiting time for the patient).

In the reception, time is used to keep an eye on the screen (function marked with a red '2' in figure 14) and to remind and guide patient to the right blood sampling room (function marked with a red '3' in figure 14). To management, the two functions were unknown.

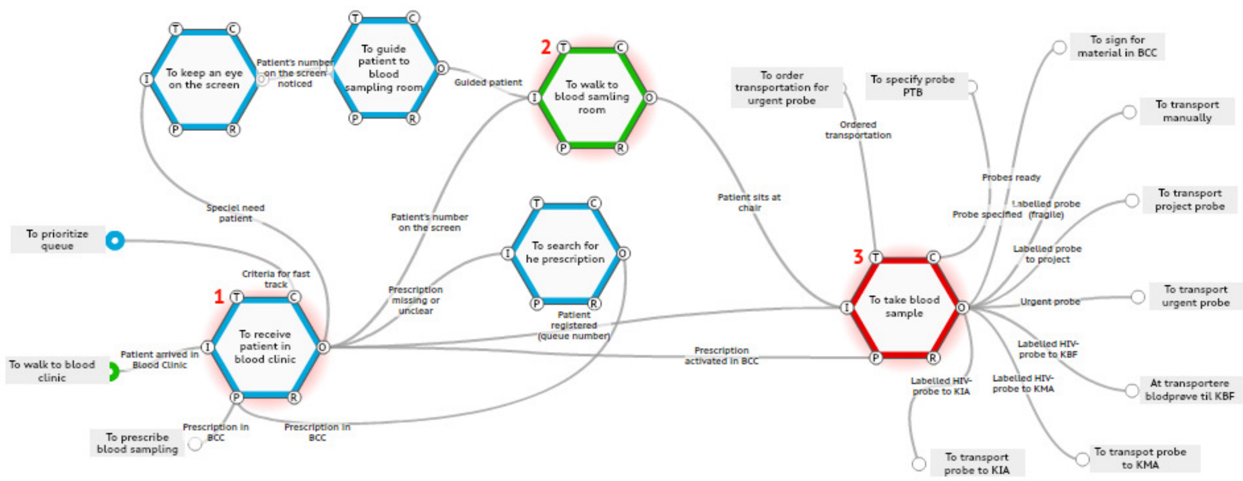
Figure 14 Instantiation 2 of FRAM 4 Blood sampling



The third instantiation of the FRAM 4 model shows the situation where the patient interferes in the functioning of the system and goes to a different room than indicated on the screen, see figure 15.

The interference affects the functioning of the system in two ways: 1) Time is lost if the phlebotomist, waiting for the patient, is using time to try and find the patient, 2) Time is lost, because the phlebotomist accepting the patient has to update the system.

Figure 15 Instantiation 3 of FRAM 4 Blood sampling



The three instantiations showed the health care professionals and the management the difference between work-as-imagined (the LEANed workflow) and work-as-done. The three instantiations also gave the health care professionals and management a common understanding of how the expected time saving got lost through the use of more time to make the system work.

Chapter 7.3.4 describes the opportunities for improvement proposed by the health care professionals involved in the FRAM 4 analysis.

7.2.5. Summary Functional Resonance

The FRAM model instantiations explains how the adjustments of everyday work ensure the safe and effective functioning of a system, but also why the very same adjustments sometimes can result in an unwanted or unexpected outcome for the patient, due to functional resonance.

Common for the four FRAM analyses is that the adjustments in themselves cannot explain an unwanted or unexpected outcome for the patient. The FRAM models show how the performance variability of a function can couple with the performance variability of other functions, and the unwanted or unexpected outcome for the patient emerges.

7.3. Opportunities for improving patient safety

One way to avoid functional resonance is to dampen the variability of one or more functions. Another way is to avoid coupling of performance variabilities that can emerge into functional resonance.

The chapters 7.3.1 to 7.3.4 describes the opportunities for improving patient safety, identified through the instantiations described in chapter 7.2.

7.3.1. FRAM 1 Ward rounds

Through the FRAM analysis and model, the health care people realized how their behaviour resulted in a start of the ward rounds somewhere between 9 am and 12 midday. This variability meant that a later start would put time pressure on the functions starting after the function ‘To do ward rounds’ (down-stream functions). In worst case, the patient’s stay would be extended for 24 hours, which could affect patient safety (higher risk for infections and pressure ulcer).

Through dialogue, the health care people decided as a first step to start the ward rounds at 9 am. From the FRAM model, see figure 5, the health care people knew that the decision would put time pressure on the up-stream functions, e.g. 'To measure early warning scores', 'To prepare – the physicians', 'To prepare – the nurses' and 'To receive test results from laboratory'. These four functions were preconditions for the function 'To do ward rounds', e.g. the success of the function would depend on the performance of these four functions.

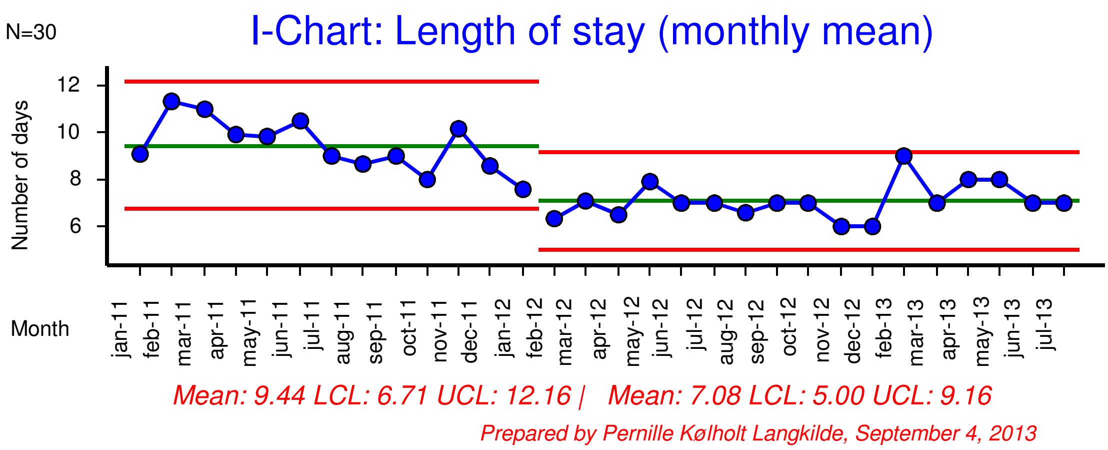
In addition, the ward management decided that the physician in charge of a specific ward round should not receive phone calls during the ward round. The physician should hand over the phone to another physician on duty. The function 'To call the physician in charge of the ward round' was therefore no longer affecting the function 'To do ward rounds'.

Next step was to ensure the preconditions for the function 'To do a ward round'. The ward management agreed with the laboratory to mark probes with 'urgent' for both the urgent patients and the patients that were scheduled to be discharged the same day. The marked probes would be tested first in the morning.

The third step was to reorganise the activities in the morning prior to the start of the ward rounds, leaving time for the physician and the nurses to prepare for the specific ward round and to measure the early warning scores.

The implementation of the improvements resulted in a marked reduction in the length of stay from a monthly average of 9.4 days to 7.1. days, see figure 16.

Figure 16 Control chart for length of stay (monthly mean)



7.3.2. FRAM 2 Spine Fracture

Through the FRAM analysis and the instantiation of the FRAM model, the health care people involved in the spine patients pathway realised that the habit of writing only the main findings and not incidental findings in the heading of the test result – critical or not, could propagate into a patient safety incident, see chapter 7.2.2.

The hospital unit preparing the report of the test results agreed to change the habit. By changing the structure of the test result report and bring important information to the heading, including critical incidental, the improvement would contribute to doing things right in the down-stream function done by the General Practitioner (GP) 'To read test result' (function marked with an red '8' in figure, see figure 11).

The change did not result in the use of more time and resources at the hospital unit.

7.3.3. FRAM 3 Pre-evaluation of patients with back pain

Through the FRAM analysis and the instantiation of the FRAM model, the six physicians doing the pre-evaluation realized that their individual ways of making subcategories of the category 'Urgent' compromised the correct priority of the urgent patients, see chapter 7.2.3. The physicians agreed on having only two categories for urgent patients - 'Urgent' and 'Very urgent'. The patients in the two categories should be booked in chronological order. Management approved the change.

7.3.4. FRAM 4 Blood Sampling

Through the FRAM analysis and the three instantiations of the FRAM model, see chapter 7.2.4., the management and the health care professionals at the blood clinic decided to change the workflow. By changing the electronic registration system, it is possible to register a patient to a preferred phlebotomist and to mark a patient that needs help, so that the phlebotomist as an exception can fetch the patient.

In addition, the management of the blood clinic wanted to make a deeper investigation of the challenge with the missing prescriptions, to avoid wasting time in the reception.

7.3.5. Summary Opportunities for improving patient safety

A FRAM analysis and a visualization of the result of the analysis through the FRAM model, makes it possible for the management and the healthcare people to identify opportunities for improvement.

After having participated in a FRAM analysis (FRAM 3) a physician said, that '*it is easy to see what to do to improve*'. Another physician said, that '*FRAM gave us a common understanding and made us see, what we could not see before. Now we have seen it, we can do nothing less than act*'.

This study has shown that small adjustments can have a large impact on the patient's outcome, but also that small changes can dampen the performance variability to ensure that '*things go right*'.

7.4. Patterns in FRAM models

This study include four out of about 30 FRAM analyses, prepared in the period from March 2012 to February 2016. When looking at the large numbers of FRAM analyses some patterns emerge. These patterns relate to the behaviour of the health care professionals when coping with the complexity of the system. The behaviour ensures the safe and effective functioning of the system, by dampening the variability. At the same time, the very same behaviour sometimes results in an unwanted and unexpected outcome for the patient (resonance). Table 16 highlights four of these patterns.

Table 16 Patterns with the potential to dampen or increase (resonance) performance variability in a complex system

No.	Description of patterns
1	Behaviour of health care professionals in upstream functions that results in disturbances or interrupt an actual function, reducing the time available to do the function
2	Health care professionals' introduction of permanent and not formally defined functions to cope with variations in everyday work. Individual mnemonic systems and individual priority systems are examples of such functions.
3	Health care professionals' introduction of intermittent functions to cope with variations in everyday work that sometimes show up
4	Assumptions about how others do their work and the believe that they have the same knowledge and basis as yourself

Pattern 1 is disturbances and interruptions of on-going work. The disturbances and interruptions take time from the actual function, reducing the time available to do the function and often resulting in a trade-off between efficiency and thoroughness (ETTOing) to gain time to finish the function in an acceptable way.

FRAM 1 showed that during a ward round phone calls disturbed and interrupted the physician in charge. The calls took time from the ward round and put an increasing work pressure on the physician. The physician had to make up for the lost time and could gain time by being less thorough or skipping consultations with patients. If the ward round finished later than midday, the patients had to stay in the ward for additional 24 hours, with an increasing risk of infections, falls and pressure ulcers. The patients would also unnecessarily occupy a bed in the ward, causing waiting time for other patients or overcrowding of the ward. Both could be crucial for the patients because they are elderly and vulnerable citizens.

Disturbances and interruptions of functions have a potential for large variability (resonance), especially when health care professionals need to be thorough to ensure an acceptable output of a function.

Pattern 2 is when the health care professionals need to introduce permanent and not formally defined functions to cope with variations in everyday work.

The FRAM analyses showed that health care professionals use individual mnemonic systems to help them remember; for example prints of a journal on the desk, notes in a diary, Post-Its on the desk or screen. An individual mnemonic system is normally not shared with colleagues and represents therefore hidden knowledge. Normally an individual mnemonic system works, but the system's safe and effective functioning depends totally on one person.

FRAM 4 showed that the receptionist in the blood clinic had an individual mnemonic system to help remember patients with special needs. If the receptionist was very busy, disturbed or interrupted, the mnemonic system could fail to work and the patients had to wait longer than expected for the blood sampling. In worst case, these patients would wait to the end of the working day, where the receptionist would wonder why patients were still in the waiting room.

FRAM 3 showed that the six physicians at the Spine Centre expanded the category 'Urgent' to include individual subcategories to cope with patients that were more urgent that other urgent patients. Each physician had own subcategories and it was difficult or even impossible for the medical secretaries to book the patients in the correct order of urgency. The individual priority systems of the physicians could result patients that are less urgent overtaking patients that are more urgent. The result of misinterpreting the individual subcategories could be that patients had to wait longer for an appropriate treatment, resulting in a less chance of recovery.

Like an individual mnemonic systems, an individual priority systems compensate for a need not met by the formal system. An individual priority system also represents hidden knowledge and has the potential of resonance.

Pattern 3 is intermittent functions that the health care professionals need now and again to ensure the effective and safe functioning of the system. They emerge when needed and disappear when not.

The FRAM analyses showed that intermittent functions could dampen performance variability of upstream functions. The health care professionals activate the functions when they recognize a situation. They act 'as if' they followed the ETTO rule *'It looks like a Y, so it probably is a Y'*. The disadvantage of intermittent functions are that few in the actual work situation only know them and that the need to start the functions depends very much on the experience of the staff. Less experienced staff would not know the functions or recognize the situation when to use them. Often intermittent functions represent a violation of the formal system and less experienced staff therefore would avoid using them.

In FRAM 3, the medical secretaries had to decide the final priority of the patients in the category 'Urgent' because of the physicians' individual subcategories for this group of patients. Depending on the physician doing the actual pre-evaluation, the medical secretaries would need the function 'To prioritise 'urgent' patients', to be able to book the patients in an effective way.

FRAM 4 showed that when patients with special needs arrived at the blood clinic, two intermittent functions 'To keep an eye on the screen' and 'To guide patient to blood sampling room' would emerge to ensure the blood sampling of these patients.

Pattern 4 is assumptions on how other people do their work both upstream and downstream of the actual function. The assumptions result in a behaviour 'as if' the ETTO-rules '*It has been checked earlier by someone else*' or '*It will be checked later by someone else',* are followed. Assumptions save time but have the potential of increasing performance variability (resonance), if the assumptions are incorrect.

In FRAM 2, the General Practitioner (GP) of the patient assumed that the hospital highlighted all critical findings in the heading of the CT-scan report. This assumption resulted in neglecting a critical incidental finding and delayed the appropriate treatment of the patient for five months. At the same time, the health care professionals at the hospital assumed that the GP read all the text of the CT-scan report and not only the heading.

In FRAM 3, the six physicians at the Spine Centre assumed that the other physicians followed the procedure and only used two categories when pre-evaluating - 'Normal' and 'Urgent'. The physicians were not aware that each of them had developed subcategories of 'Urgent' and that this behaviour could result in an incorrect priority of the patients related to urgency.

FRAM 4 showed that the assumption that all patients complied with the new LEANed workflow, did not reflect reality. Some patients did not have the cognitive ability to use the system and some patients violated the system to promote their own interest by walking to another room than the one indicated on the screen in the waiting room.

7.5. Summary of the data analysis

The result of analysing the data collected through semi-structured interviews of the health care people actually doing the work, shows that the ETTO and TETO principle can make adjustments in everyday work understandable. The work related ETTO rules give a common explanation – 'as if' – of the behaviour of the health care professionals in the system.

The data analysis demonstrates through the FRAM models how adjustments lead to performance variability and how the variability can propagate through the system. Sometimes the variability is increased into an unexpected and unwanted outcome for the patient (functional resonance).

The FRAM model is valuable platform for identifying opportunities for improving patient safety in everyday work and helps management and health care professionals to agree on suitable patient safety interventions

There are common patterns in the adjustments of everyday work. One is upstream functions that disturb and interrupt a function and thereby reducing the time available to do the work. Another is permanent and not formally defined functions like individual mnemonic and individual priority systems. The third intermittent functions to cope with variations in everyday work that sometimes show up and finally assumptions on how others do their work and basis and knowledge they have to perform.

8. Discussion

The purpose of this study was to investigate how health care professionals adjust everyday work to ensure the safe and effective functioning of the system. The investigation included a description and modelling of everyday work to understand how the very same adjustments can couple and emerge into an unwanted and unexpected outcome for the patient.

The FRAM and the FRAM Model Visualiser (FMV) were used to describe and model four cases from health care settings in the Region of Southern Denmark. The four FRAM analyses and models showed how managers and health care professionals can use the description and model as a platform to identify opportunities to improve patient safety.

Of the four cases in this study, one used the FRAM as a tool for analysing a reported patient safety incident (FRAM 2: Spine fracture) and three used the FRAM as a risk assessment and improvement tool (FRAM 1: Ward Rounds, FRAM 3: Pre-evaluation of patients with back pain and FRAM 4: Blood sampling). Chapter 8 discusses different issues related to the use of the FRAM and the FMV.

Chapter 8.1 compares the fundamentals of the two methods RCA (Root Cause Analysis) and FRAM. The reason for choosing RCA is that RCA is the most common method when investigating patient safety incidents at the public hospitals in Denmark. Chapter 8.2 describes how the findings of this study fit in with other theories and views in the field. The chapter includes the sociologist Charles Perrow's theory of 'normal' accidents and his views on complex systems [Perrow, 1999], the safety expert and psychologist David Woods and his associate the anaesthesiologist Richard Cook and their 'Tale of two stories' [Woods et al, 1998], and finally the psychologist James Reason's view on the FRAM [Reason, 2016].

8.1 FRAM compared to RCA

Organisations use methods like RCA and FRAM to describe and analyse the real world in a manageable way. RCA is an analytic approach that seeks to identify the root cause of an incident. FRAM is a modelling tool, which use does not depend on an incident. FRAM supports development of a model that can be used to explain an incident. However, frameworks and methods are simplifications built on assumptions that have their own limitations. They are filters through which the analyser looks at the real world. [Akselsson, 2014]

The underlying accident model of the RCA are originally the 'Domino' model with development into the 'Swiss Cheese' model as organisation factors were recognized as significant. [Akselsson, 2014]

The FRAM has no underlying model but is based on four underlying principles: equivalence, approximate adjustments, emergence and resonance, described in chapter 5.1. A model of the actual situation is build and analysed. The model is visualized with the FMV, showing the interactions and dependencies between the functions in the work situation. The FRAM is not a safety analysis method; it is a modelling method. Unlike the majority of other safety methods, FRAM models everyday work and is not dependent on something that goes wrong. FRAM models the actual work situation even when that is a safety incident [Hollnagel, 2012a].

Table 17 summarizes the difference between the methods RCA and FRAM as to basic assumptions.

Table 17 The basic assumptions of the methods RCA and FRAM

Basic assumptions	**Root Cause Analysis (RCA)**	**Functional resonance Analysis Method (FRAM)**
Underlying thinking and model	Safety-I Linear systems that can be decomposed into components that are coupled in a sequence. When a component malfunction it can start a cause and effect chain Domino-model and Swiss Cheese model	Safety-II Non-linear (complex) systems, consisting of functions that couple from tight to loose No model but four underlying principles
Learning perspective	Learning from things that go wrong	Learning from things that go right
Approach to improve Patient Safety	Reactive, e.g. act on something that has happened Analysing the incident to find malfunctioning components (causes) People are a component that can malfunction People's adjustments should be avoided	Both reactive and proactive, e.g. act on something that has happened and act on situations in everyday work Analysing the performance of everyday work to identify adjustments and the resulting performance variability. Predicting how the variability can couple and sometimes become unexpectedly large (functional resonance) People are a resource that make the system work People's adjustments ensure the safe and effective functioning of the system

When methods are used in everyday practise, it is common not to question the basic assumptions. In some cases the basic assumptions are not even known. This is in itself an example of ETTO – a trade-off between efficiency and thoroughness, because we do not consider the situation in detail in order to select an suitable method. Sometimes methods are used due to fashion, sometimes because they are regulated; sometimes they are the only methods we know. One of the premises of FRAM is that perhaps some of those methods have not actually worked ad we need to look further.

Lundberg et al (2009) describes that '*what you look for is what you find*'. As shown in table 17, RCA and FRAM are based on very different basic assumptions explaining how accidents happen and what the important factors are. Because they view an actual work situation from very different perspectives, they find very different explanations of why a patient safety incident happened.

One of the cases in this study (FRAM 2) is a patient safety incident: A patient with back pain received inappropriate treatment for nearly five months, despite the fact that a CT-scan showed an unstable spinal fracture. The incident did not lead to permanent harm. However, the patient endured considerable back pain, while waiting for the correct treatment, see chapter 6.3.2.

An RCA explains the patient incident by means of a cause-effect chain and looks for a component in the chain that malfunctioned. It is likely that the RCA would point at the General Practitioner (GP) as the malfunctioning component that started the chain leading to the patient safety incident. The GP missed the critical incidental finding by only reading the heading of the CT-scan report. The patient safety recommendation based on this finding is a proposal to the GP to be more thorough and read the full text. Implementing the change forces the GP to use more time, leaving less time to other patients.

A FRAM analysis would consider the patient safety incident in light of everyday work. The FRAM analysis explains the behaviour of the GP as a well-established routine that has shown itself to be effective, normally giving the wanted outcome for the patient. The routine reflects a trade-off between efficiency and thoroughness in everyday work where the GP gains time for other patients. The FRAM analysis considers the GP as a resource and aims for supporting the successful completion of everyday work. A patient safety recommendation is likely to support the well-established routine, by bringing both main findings and critical incidental findings to the heading of the CT-scan report. This would mean a change in the working routine at the hospital, with no additional time and resources needed.

The step 1 in the FRAM analysis is to model everyday work. The instantiation of the model depicts the actual situation from which recommendations can be made to dampen the performance variability. Table 18 shows examples of variability dampening recommendations with regard to the function 'To read test report' in the FRAM model 2, see figure 11.

Table 18 Recommendations to dampen performance variability in the FRAM model 2 for the function 'To read test report' (the case 2 Spine fracture)

Function/no. in figure 11	**Relation the function 'To read test result'**	**Recommendation**	**Use of time and resources**
To evaluate the suspicion of cancer / 5	Upstream function	To contact the GP by phone, both by critical main findings (cancer) and critical incidental findings (unstable spine fracture)	Increased use of time and resources at the hospital
To prepare report / 6	Upstream function	To highlight both critical main findings (cancer confirmed) and critical incidental findings (unstable spine fracture)	Unchanged
To forward test result to another specialty in the hospital / new function	Upstream function	To forward critical incidental finding (unstable spine fracture) directly to the spine surgery department	Increased use of time and resources at the hospital. In addition a new routine.
To investigate patient /12	Upstream function	To reassess the patient's history and all the prior test results	Unchanged or increased use of time and resources at the GP

As the examples show in table 17, FRAM describes the work situation from a broader perspective and captures the complexity in the work situation. The FRAM analysis provides a systemic perspective on the work context and the resulting performance variability. The FRAM offers a greater choice in the solutions it recommends and more practical solutions, as they are a better match for what is actually happening in the workplace.

Woltjer and Alm (2009) confirmed these findings in a study. They applied the FRAM to investigate a patient safety incident where surgical materials were left in a patient's abdomen during a surgical procedure. The result of the investigation was compared to the result of an investigation prepared by a patient safety unit at the County Council in Östergötland, Sweden. The unit used RCA combined with human, technological and organisational aspects to investigate the very same incident. The conclusion of the study was that the analysis with FRAM '*had a number of advantages most prominently because of its facility to expose the complexity often found in the health care domain*' and that '*FRAMs more extensive investigation process facilitates finding more complex and systemic interdependencies than other methods may allow*'.

Compared to RCA, FRAM is a powerful tool for analysing complex socio-technical systems because the method unveils functional interdependencies and non-linear effects of performance variability.

8.2. Other views in the field

8.2.1. Normal accidents

Perrow (1999) introduced in 1984 the idea of 'normal' accidents. Perrow's message was that most safety critical systems have two characteristics that make accidents inevitable. First is the type of interactions between elements in the system (linear versus complex) and second is the type of coupling (loose versus tight) between elements in the system.

Linear interactions between elements in the system are known, expected, planned and can be fully described and understood. Complex interactions are unknown, unexpected, not planned, and cannot be fully described and understood.

Couplings between the elements in the system are the degree to which the elements connect or depend on each other. In loosely coupled systems, delays are possible and elements can wait without affecting the performance. Substitution of resources is possible and wasted resources will not overload the system. In addition, there are many ways to reach the goals and the sequence of the elements in a loosely coupled system can vary. In tight-coupled systems, delays are not possible and the elements in the system cannot wait. Substitution of resources is not possible and wasted resources will overload the system. In addition, there is only one way to reach the goal and the sequence of the elements are invariant [Perrow, 1999] [Akselsson, 2014].

FRAM reflects Perrow's view of systems and emphasizes that we cannot understand why things can go wrong without understanding the variability of everyday work.

The four FRAM models in this study describe the potential couplings between functions in the work situations. Instantiations describe the actual couplings. Thus, FRAM models describe how the performance variability of a function can propagate through the couplings and sometimes increase unexpectedly (resonance).

As shown in the four FRAM models in this study actual couplings in everyday work can differ from the couplings that were intended when the system was designed. One example is the FRAM model (FRAM 4) of blood sampling. The model of how the work actually was done (work-as-done) differed from the redesigned and standardized workflow (work-as-imagined). The standardized workflow was designed so that the phlebotomist could stay in the blood sampling room and not use time fetching the patient in the waiting room. The FRAM model showed how the redesigned workflow had not taken into account the special need of patients with low cognitive capacity and the behaviour of patients familiar with the work processes in the blood clinic.

As mentioned in chapter 2, health care systems are complex systems. Hollnagel (2013) argues that a specific patient's pathway will reflect both loosely and tightly coupled functions and both linear and complex interaction between functions. This study showed that a FRAM model can enable the user to visualize the functions in the patient's pathway, their couplings and interactions.

An important statement of Perrow (1999) is that '*on the whole, we have complex systems because we don't know how to produce the output through linear systems*'. FRAM describes how a system actually works and gives a broad view on how to improve the system to ensure a safe and effective functioning.

8.2.2. 'A tale of two stories'

David Woods and Richard Cook distinguish between first and second stories about why accidents happens. [Woods et al, 1998]

In the first story, it seems so clear in hindsight how the incident could have been avoided if the health care professionals involved had recognized the significance of the situation or if they had been more thorough in carrying out the work. The first story reflects the Safety-I thinking where we follow the chain of events back and find the malfunctioning component that lead to the incident.

The second story is the detailed investigation that reveals the multiple vulnerabilities of the complex system, detecting the adjustments that the health care professionals need to do to cope with the system. Digging for the second story promotes learning about systemic vulnerabilities and how success and failure are closely related [Woods et al, 1999].

One important message in '*The tale of two stories*' is to avoid accepting the first story as the true explanation of how the incident happened and depend on the first story as the basis for patient safety interventions.

When the findings of this study are interpreted in terms of '*The tale of two stories*', the first story tells what people should have done in the situation. In the example with the unstable spine fracture, example 2 in this study (see table 3 in chapter 6.1), the first story would indicate that the GP should have read the full text of the CT-scan test report. The GP should have been more thorough. However, the first story does not explain why it made sense for the GP to do what he/she did.

A FRAM analysis tells both the first and the second story through the FRAM model. The FRAM analysis explains why it made sense for the GP to only read the headings in the CT-scan report: The GP did not read the full text of the CT-scan test report because the heading normally would reflect the result. The routine was normally effective, mostly went right, and helped the GP gain time for other patients. The vulnerability of the system was that there was not enough time to be thorough and the GP had found a way to move towards efficiency.

8.2.3. The 'Swiss Cheese' accident model

James Reason developed the 'Swiss Cheese' accident model, described in chapter 5.1. In his new book, Reason (2016) acknowledges FRAM and resilience as a possible way forward to improve safety in complex systems.

It is important that Reason acknowledges the importance of FRAM/resilience. This is a sign that the field of industrial safety is starting to recognize the limitations of linear methods, and looking to methods such as FRAM, that can cope with complexity:

- ✓ '*Among the alternative approaches………, there is none more alternative or powerful than that recently presented by Erik Hollnagel*' (Author: FRAM)

- ✓ *'….the world of complex sociotechnical systems is anything but simple. 'Swiss Cheese-type' metaphors are easily understood and disseminated – yet maybe we need to move on and FRAM could be one of the ways forward'*

It is also important to experience how well the FRAM was received by the practitioners in health care. One of the narrative stories collected during the FRAM analyses at the hospitals in the Region of Southern Denmark reflects Reason's view in other words. A physician involved in a FRAM analysis responded that '*FRAM made us notice what we could not see before, and now when we have noticed it, we cannot but react on it*'. Another physician said that '*FRAM has given of a language and a common understanding of how things really work and how we can change into the better*'.

9. Conclusion

This study aimed to answer the question: How can the description of adjustments of everyday work be used to improve patient safety in health care settings. To answer the question the study investigated adjustments of everyday work in four different situations from three different public hospitals in the Region of Southern Denmark.

The study has demonstrated that the FRAM is a structured way to get information about the adjustments and the performance variability in everyday work. The health care professionals are aware of the adjustments they make and can describe them, but they are not aware of how the adjustments sometimes can emerge into an unwanted and unexpected outcome for the patient. The FRAM model of an actual work situation helped the health care professionals to realize that even small adjustments in everyday work can lead to an unwanted and unexpected outcome for the patient. The FRAM model explained why an actual patient safety incident happened, not caused by a failure in the system but the performance variability of everyday work.

FRAM analysis built on the FRAM model provided a detailed description of everyday work and gave a shared insight into how everyday work actually was performed, for example with regards to:

- ✓ The conditions to complete everyday work successfully
- ✓ The difference between work-as-imagined and work-as-done
- ✓ The interactions and dependencies between functions in an actual workflow
- ✓ Functions where thoroughness is needed for a successful completion
- ✓ How well-established routines normally ensures the safe and effective functioning of the system, but sometimes lead to unwanted and unexpected outcome for the patient
- ✓ How well established effective routines can be improved from a patient safety perspective without decreasing the efficiency.

The FRAM models helped management and health care professionals to identify opportunities for improving patient safety in everyday work and to predict the consequences of a change.

The ever-present use of an individual mnemonic or priority system was a common finding that puzzled the health care professionals. The FRAM analysis made them realise that these individual systems ensure the safe and effective functioning of the system but also are catalysts for patient safety incidents. Openness about these individual based systems are necessary to dampen the potential negative effects on the patient outcome.

10. The way forward

The finishing of this study opens up for further questions to be answered. The chapter 10 describes two areas of interest: Coping with underspecified systems (chapter 10.1.) and enhancing individual and organisational learning (chapter 10.2.).

10.1. Coping with underspecified systems

Hollnagel states that in order to get through the workday ETTOing '*is normal, necessary, and useful*' in a complex socio-technical system. The question is why whatever we do seems to require a trade-off between efficiency and thoroughness.

The answer is, according to Hollnagel (2009), that '*adjustments are necessary whenever the situation or the working conditions are underspecified*', e.g. the situation is not fully described and understood and disturbances/interruptions occur. When something is underspecified, it is uncertain how long it will take to do it and how much time there is available to handle disturbances, interruptions or unexpected demands. In an underspecified system, it therefore makes sense to people to reduce the time spent on doing something, to gain time for other demands or to reflect about everyday performances, e.g. to improve and to learn.

The focus of the FRAM is the conditions for a successful completion of functions. The FRAM is a suitable method to answer questions like:

- ✓ What does the function transform?
- ✓ What starts the function?
- ✓ Which conditions must be fulfilled before the function can be carried out?
- ✓ What resources does the function need when carried out?
- ✓ Which temporal constraints affect the function, for example disturbances and interruptions?
- ✓ How to control or monitor the function while carried out?
- ✓ What is the potential performance variability of the function (output)?
- ✓ Which functions are upstream of the function?
- ✓ How the performance variability of upstream functions affect the function?
- ✓ Which functions are downstream of the function?
- ✓ How the performance variability of the function affect downstream functions?

Most of all, the FRAM model describe the potential couplings of functions in a work situation and capture the dynamics of a complex system.

One area for future investigation is whether a FRAM model can help management and health care professionals to ensure good quality in an underspecified system.

10.2. Enhancing individual and organisational learning

When the Danish Government passed the '*Law of Patient Safety'* in 2004, the main goal was to ensure that health care professionals and providers learned from the reported incidents. The status report for the national reporting system, published in July 2014, concluded among others that improving and learning still needed to be enforced. [Danish Ministry of Health, 2014b]

Everyday work represents how the system works and gives a chance to learn from something that happens often. Organisations do not need to wait for fatal and serious incidents to happen. However, learning from things that go right in health care settings requires a change in the way we approach the system:

1. We must recognize that health care systems are complex systems and the patient pathways reflect both loosely and tightly coupled functions and both linear and complex interactions and dependencies between functions in everyday work
2. We must recognize that health care professionals are a resource, ensuring the system to function safe and effective
3. We must recognize that the key to improve patient safety is the health care professionals' adjustments of everyday work, in addition to reported patient safety incidents
4. We must understand the way individual and the organisations learn in a health care setting.

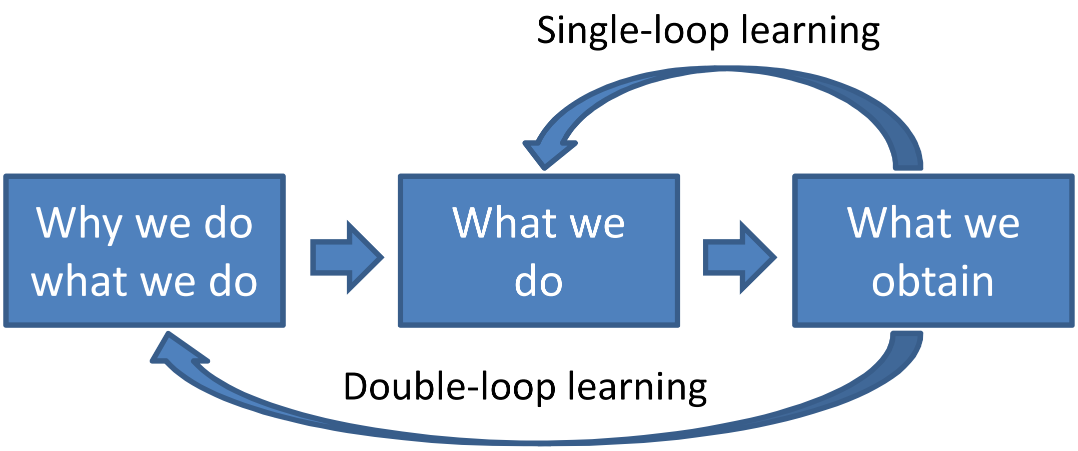
Argyris and Schön (1978) describe an important perspective related to organisational learning. They distinguish between single-loop and double-loop learning.

Single-loop learning is present when goals, values, frameworks and, to a significant extent, strategies are taken for granted. In single-loop learning *we assess what we obtained by re-assessing what we did until we succeed.* The emphasis is on 'techniques and making techniques more efficient' and involves following routines and plans. [Usher et al, 1989]

Double-loop learning, in contrast, involves questioning framework and learning systems that underlie goals, values and believes. In double-loop learning *we go deeper and address why we did what we did*. The double-loop learning is more creative and reflexive and involves consideration notions of the good. Reflection is more fundamental and the basic assumptions of the organisation are confronted. [Argyris, 1982]

Figure 17 illustrates the single-loop and the double-loop learning.

Figure 17 The single-loop and the double-loop learning



Argyris (1974) (1982) (1990) argues that double-loop learning is necessary if practitioners and organisations are to make informed decisions in rapidly changing and often uncertain contexts as we see in the health care system.

An area for future investigation is how FRAM models can help health care professionals and providers (organisations) to increase their capacity for double-loop learning.

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Appendix A: Literature search

Table 19 shows the key words used in the literature search and the databases included.

Table 19 Key word and search databases

Key words used in the literature search	Databases included in the search
Adaptive system(s) Adjustment(s), adjust + complex system(s) Complex + system(s) Complex socio-technical system(s) FRAM Functional resonance Functional Resonance Analysis Method Human process(es) Resilient organisation(s) Resilience Resilience engineering Resilient health care Variability and process(es)	Business Source Complete The database is interdisciplinary and covers all disciplines of business, including marketing, management, accounting, banking, finance, and more. Web of Science The database is interdisciplinary and goes across sciences: Natural sciences, biomedical sciences, engineering, social sciences, arts & humanities. Scopus The database is interdisciplinary and goes across sciences: Biomedical sciences, natural sciences, engineering, social sciences, arts & humanities. PubMed PubMed er en amerikansk database, som indeholder mere end 24 millioner citationer til biomedicin og sundhed, dækkende dele af biovidenskab, adfærdsvidenskab, kemiske videnskab og bioteknik.

Examples of search results:

- ✓ A search in the database 'Business Source Complete' with the key words 'Adjust*', 'and Complex* system*' gave 276 hits. The librarian recommended not to add more key word, but to see the through the list manually.
- ✓ A search in the database 'Web of Science' with the key words 'Adjust*', 'and Complex* system*' gave 276 hits. Adding the key word 'Human process*'gave 0 hits. Substituting the key word 'Human process*' with 'resilien*' reduced the number of hits to 69.

Appendix B: The six aspects of FRAM

Table 20 defines the six aspects of FRAM [Hollnagel, 2012a] [Hollnagel et al, 2014]

Table 20 Definition of the six aspects of FRAM

Aspect	Description
Input	That which activates the function and/or is used or transformed to produce the output. Constitutes the link to upstream functions
Output	That which is the result of the function. Constitutes the links to downstream functions
Control	That which supervises or regulates the function, e.g. plans, procedures, guidelines or other functions
Resource	That which is needed or consumed by the function when it is active
Precondition	System conditions that must be fulfilled before a function can be carried out
Time	Temporal aspects that affect how the function is carried out (constraint, resource)

Appendix C: The questionnaire

During the interview, a questionnaire was used for guidance. The questionnaire were prepared specific for each interview, covering the actual function. Table 21 shows common questions for all functions. The questions are shown in *italic*. Comments reflect the authors experiences from the interviews.

Table 21 Common questions for the six aspects

Aspect	Typical Questions
Input	*What will start the function?* The interviewer must be persistent and use the person's first answer to prepare a new question getting the exact knowledge of the start of the function.
Output	*What is the output of the function?* Here the interviewer ask to both the product/service and the documentation. Just like the input, the persons answer is used to ensure knowledge about the possible outputs.
Control	*How is the function controlled?* *How is the mission and vision of the company affecting the way you do the function? And the politics?* *Which goals have been defined for the function?* If the person does not mention protocols, procedures and instructions, the interviewer should not ask specifically. Protocols, procedures and instructions reflect work-as-imagined (WAI) and the focus for the interview is work-as-done (WAI).
Resource	*Which resources are you using to do the function? Hardware, software, people.* *Which competences are required to do the function?*
Precondition	*What should be in place before you start the function?* *Can you start the function without the conditions met?* *How would it affect the output?* By focusing on how the output is affected, the interviewer get a picture of the variability of the output and the understanding of how this variability can move through the system by affecting downstream functions.
Time	*If you were under time pressure, would you do the activity differently?* *Would you do the job later?* *Would you not do the job at all?* *How would it affect the output?* By focusing on how the output is affected, the interviewer get a picture of the variability of the output and the understanding of how this variability can move through the system by affecting downstream functions.

Appendix D: Notes from interviews

The notes were typed and coded in Danish by the author according to the six aspects of a function. The appendix shows the notes for the function '*To pre-evaluate patient at the Spine Centre*'. Similar notes exist for the other functions in this study.

Function 5: To pre-evaluate patient at the Spine Centre

Noter	Interview i **Rygcentret**, Middelfart Sygehus, med en visiterende læge og en lægesekretær, den 23. november 2012. Interviewet blev gennemført af Lise Nottelmann og Jeanette Hounsgaard.
Funktion	Visitation af patienter i Rygcentret
Beskrivelse af funktionen	Rygcentret er et ambulatorium og har ikke akutte patienter, kun henviste. Henvisninger modtages enten gennem GS (Grønne System), med post, med fax eller Medimail. Alle henvisninger, uanset modtagelse, printes ud på papir, stemples og lægges efter grovsortering af en sekretær i bakken til visitator. Visitator tømmer bakken tre gange om dagen og visiterer henvisningerne. Alle henvisninger visiteres normalt samme dag, som de er lagt i bakken af sekretæren. I forbindelse med visiteringen sorteres henvisningerne i seks forskellige kategorier: *Akutte, Kirurgbunken, Fremskyndet inden for 14 dage, Fremskyndet med pil opad, Afvisning* og *Almindelige* (alle andre). Ved *Akutte* tager den visiterende læge straks fat i rekvirenten eller patienten med henblik på en akut behandling. Henvisningen afvises derefter. Sorteringen afgør det videre forløb for de enkelte patienter.

Beskrivelse af de seks aspekter og variabiliteten

<u>Input:</u>

Henvisning (post, fax, medimail)

- Alle henvisninger, uanset modtagelse, printes ud på papir, stemples og lægges efter grovsortering (se kontrolaspektet) i bakken til visitator – samme dag eller dagen efter. Nogle print giver en meget lille tekststørrelse.
- Bakken med henvisninger tømmes ca. tre gange om dagen af den visiterende læge. Morgenbunken er som regel den største.
- Post: Kommer ind i hovedpostkassen. Afleveres af den interne post ved sekretærerne, som åbner posten og videregiver henvisninger til de to sekretærer, som håndterer henvisningerne.
- Fax: Specielt fra kiropraktorer. Fax kan komme ind på flere maskiner. Tjekkes, når en sekretær kommer forbi, tømmes og afleveres til de to sekretærer, som håndterer henvisningerne. Fax er samtidig en almindelig printer, hvor der også udskrives generelt – risiko for at henvisningerne "putter" sig i en udskrift.
- Medimail: Korrespondancesystem, hvis der er tvivl om der i korrespondancen egentlig er tale om en henvisning, fanges dette af sekretærerne og afleveres til visiterende læge.

<u>Output:</u>

Afvist henvisning
Tid til patient

Henvisning til ‘kirurgbunken’

Variabilitet af output

Afvist henvisning

- Afvist henvisning med afkrydset afvisningsskema (årsag til afvisningen).

Tid til patient

- Tid til patienten med henblik på screening eller forundersøgelse (afhængig af kategorien)

Forudsætninger:

Fyldestgørende henvisning

Ressourcer:

Læger

- 6-7 forskellige læger visiterer, alle erfarne
- Nyansatte/nyuddannede læger varetager ikke funktionen, før efter ca. seks måneder, hvor der gives en introduktion, oplæring og supervision (følordning).
- Udfordringen er at visitere ens - diskuteres løbende på lægemøder
- På visitationsdage har lægerne ikke planlagte patienter, men en ad hoc funktion, f.eks. supervision og opkald udefra.
- Nogle læger afviser mange, andre ingen – ikke kategorisk linket til erfaring.

Patientens journal

- Ved kendte patienter, hvis tid, slås op i patientens journal og de seneste notater læses.
- Indhenter aldrig supplerende oplysninger til visitationen, men nogle gange mellem visitation og første konsultation – kan derfor visiterer uden støtte af IT-systemer

MR-scanning resultater

- MR-scannings resultater: Hvis ikke det i henvisningen er anført, hvor en MR-scanning er udført, kan billeder ikke findes frem.

Lægesekretærer

- To lægesekretærer håndterer de modtagne henvisninger

Kontrol

Visitation gennemføres hver dag

- Der visiteres hver dag. Der skal noget meget usædvanligt til, for at alle henvisninger ikke bliver visiteret samme dag, som de er lagt i bakken af sekretæren. Uanset tidspres for lægen. Hvis henvisninger ligger over til næste dag, informeres den læge, som skal visitere dagen efter.
- Har en retningslinje, der beskriver visitationskriterierne
- Undersøgelse er gennemført på ensartetheden i visitation: De visiterende læger fik de samme 20 henvisninger og skulle sortere dem i de forskellige kategorier. Der var forskelle, f.eks. i gråzonen mellem fremskyndet indenfor 14 dage og almindelige og screening eller forundersøgelse.

Sortering af henvisninger

- Sekretærerne fortager den første grove sortering:
- Direkte forkert henvisning, f.eks. til røntgen af noget, som ikke har med ryggen at gøre. Konsekvens: Rekvirent informeres om fejlhenvisning – afvises.
- Utvetydige henvisninger til f.eks. rygkirurgisk vurdering – lægges i rygkirurgernes bakke.
- Udpegning af specifikke henvisninger overfor den visiterende læge, hvis f.eks. egen læge/patienterne selv har kontaktet rygcenteret telefonisk
- Afvisning, f.eks. ved utilstrækkelige informationer eller hvis de relevante informationer ikke kommer i starten af henvisningen. Afviser lige hårdt overfor interne og eksterne

henvisninger. Tendens til at interne henvisninger bare linker til en journal ude at udpege den væsentlige problemstilling.

Sortering af henvisninger ved visiterende læge:

- Akutte: Straks telefonisk kontakt til rekvirenten eller patienten selv (udenfor egen læges arbejdstid, søge vagtlæge) – afvises efterfølgende.
- "Kirurgbunken" – sekretærerne sørger efterfølgende for at lægge henvisningerne i rygkirurgernes bakke
- Fremskyndet inden for 14 dage: Undersorteres i to grupper – screening (kun ondt i en region) eller forundersøgelse.
- Fremskyndet med pil opad: Ikke særlig veldefineret (fagligt skøn), evt. telefonisk aftale med rekvirenten, mundtlig overlevering mellem visiterende læge og sekretær
- Almindelige, alle andre, når der er tid - er elastikken i kapaciteten. Undersorteres i to grupper – screening (kun ondt i en region) eller forundersøgelse.
- Det blev oplyst af den interviewede læge, at vedkommende altid starter med at orientere sig omkring alder og henvisningsårsag. På baggrund af dette og det aktuelle tidspres, læses resten af teksten i henvisningen. Hvis henvisningen f.eks. er en rygkirurgisk undersøgelse læses resten ikke, men henvisningen lægges direkte i "rygkirurgbunken".

Instruks om den gode henvisning

- Har instruks til praktiserende læger omkring den gode henvisning. Har haft et samarbejde omkring dette med praksiskonsulenten. Har ikke gennemført lignende tiltag overfor de interne rekvirenter.

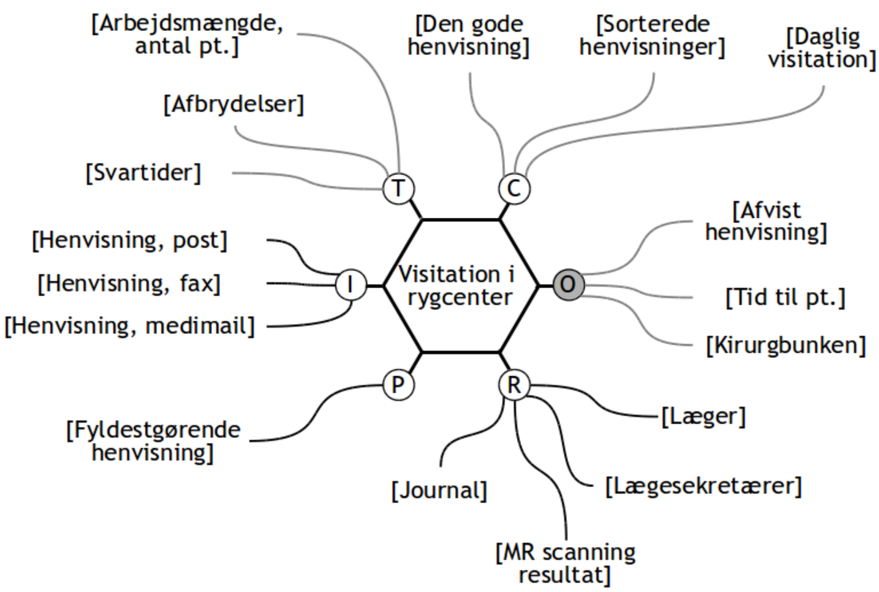
<u>Tid</u>

Tidspres (mange patienter)

- Hvis ikke tidspres, afvises færre, da der f.eks. ved manglende oplysninger tages telefonisk kontakt til rekvirenten
- Hvis tidspres: læser lange henvisninger hurtigere (citat: "risiko for at overse væsentlige informationer"), afviser flere ustrukturerede henvisninger ("De relevante oplysninger skal stå først i henvisningen"), skærer ned på den telefoniske kontakt til de praktiserende læger.

Afbrydelser

- Ad hoc funktionen for den visiterende læge resulterer i "mange" afbrydelser



Appendix E: The ETTO rules

Table 22 shows the ETTO rules [Hollnagel, 2009]. According to Hollnagel (2009) the list is not complete but include a set of characteristic or representative rules.

Table 22 Characteristic and representative rules

No.	Work related ETTO rules
1	*'It looks fine'*
2	*'It is not really important'*
3	*'It is normally OK, there is no need to check'*
4	*'It is good enough for now'*
5	*'It will be checked later by someone else'*
6	*'It has been checked earlier by someone else'*
7	*'Doing it this way is much quicker'*
8	*'There is no time (or resources) to do it now'*
9	*'We must not use too much of X'*
10	*'I cannot remember how to do it'*
11	*'We always do it in this way here'*
12	*'It looks like a Y, so it probably is a Y'*
13	*'It normally works'*
14	*'We must get this done'*
15	*'It must be ready in time'*
16	*'If you don't say anything, I won't either'*
17	*' I am not an expert on this, so I will let you decide'*