

# Innovation of the acute care system: introducing the human factor to improve quality

*analysis of a complex multi-actor system*

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## Preface

This master thesis is the final part of the two-year master of science programme Engineering and Policy Analysis. This programme is taught at the faculty of Technology, Policy, and Management, at Delft University of Technology. The programme focuses on socio-technical issues: issues that arise within society, are very complex and often involve technologies, either as a means of analysing the issue (using computer modelling techniques, for example), causing the issue (for example, nuclear power plants cause large risks) or as a solution to a problem (for instance, using high-tech machines to make railroad crossings safer). The master programme provides the knowledge and skills to deal with these complex issues, and to advise about policies.

I started this research in March 2009, knowing that I wanted to look at improving the acute care system in the Netherlands. I wanted to integrate knowledge and skills from both my bachelor degree in Industrial Design Engineering, in which I focused on ergonomics and human-machine interaction, and my master education in Engineering and Policy Analysis, in which my focus is on policy analysis and public policy making. It took some time, but I managed to combine these fields, with pleasure. The result can be seen in this report.

The research that is presented in this report is conducted within the faculty of Technology, Policy, and Management. I would like to thank everyone who helped me by supervising me, by giving an interview, by giving me useful information, and by supporting me in general during this project. I would like to thank Alexander de Haan in particular for always being there as a sparring partner to discuss problems in my research, and for being interested in the person behind the research. I remember the sentence: "No, I do not want to know about the planning, I want to know how you feel about the planning!" I also want to thank my graduation committee for giving me the freedom and space to do what I thought would be best, taking into account personal circumstances. I learned that some things cannot be planned, and the only solution is to adjust the planning (this is also very true for my research topic, acute care, in which planned ambulance rides have to make room for emergency rides). I want to thank my wonderful family and friends for being there for long conversations, discussions (about acute care), parties, and so much more. Finally, I want to thank my parents for supporting me throughout my education.

Pauline de Heer

Delft, 21 October 2009

## Summary

There are several signs that the acute care system in the Netherlands might not function optimal. This research focuses on ways to innovate, and thereby to improve the quality of the care delivered. The acute care system is: "The chain of actions aimed at providing care as soon as possible, but in any case within a matter of minutes to a few hours, to prevent death or irreversible health damage as a consequence of an acute life-threatening disorder or an accident." (Raad voor de Volksgezondheid en Zorg, 2003) The acute care system is complex. It is a large, safety-critical system in which people have to act fast and correct. Apart from qualitative, non-generalisable statements, not very much is known about the quality of acute care in the Netherlands.

### **Research setup** (see chapter 1 and 3)

The goal of this research is to gain insight into the functioning of the acute care system in the Netherlands, with a first exploration in the field of error analysis as a means to find points for improvement. Looking at the system in a holistic way is done using systems thinking.

This research leads up to a 'roadmap' that aims to offer a method for using error analysis for system innovation. The goal of the roadmap is to use knowledge about the system to create and support innovations that improve the quality of the acute care system. The roadmap is not a step-by-step guide, but rather aims to show a way of advancing the acute care system efficiently (aiming at those places where things go wrong right now) and effectively (with the right result).

The methodological approach taken in this research, especially including the human factor approach, wants to offer a new way of looking at quality and innovation of health care systems. In essence, this research is a conceptualisation of the problems within the acute care system.

The ministerie van Volksgezondheid, Welzijn en Sport (ministry of Public Health, Welfare and Sports, hereinafter called VWS) is responsible for acute care, and is able to initiate changes in order to improve the acute care system. Therefore it will be seen as problem owner.

### **Acute care system** (see chapter 2)

The routes the patient might take through the system depend on the assessment of different people with different backgrounds (medical or not) and different circumstances (stress, fatigue): it is very well possible that because of this human factor, the routes are not efficient and may lead to (permanent) health damage or death. The system communication is not working properly: it lacks communication possibilities. Besides that, there are capacity problems with the C2000 communication system.

The people working in the acute care system have heavy jobs: risks and stakes are high, and people always need to act fast and correct. The web of norms, guidelines, protocols, laws, and regulations is complex and determines the organisation of the acute care system. This automatically results in a complex system.

### **Innovation in the acute care system** (see chapter 4)

Since there are signs that the acute care system does not function optimal, and there is uncertainty about the quality of the system, it can be useful to aim for innovations that improve the quality of the system. "Successful innovation is the creation and implementation of new processes, products, services and methods of delivery which result in significant improvements in outcomes efficiency, effectiveness or quality." (Mulgan & Albury, 2003) The goal of innovating should be to increase quality.

The acute care system has a couple of obstacles in place that hamper innovation, such as inadequate resources and a short-term planning horizon. The most important requirement for an innovation-supporting system, is that it should adopt a systems view, and accept and support the human factor approach of innovation development that takes into account the different levels of the system.

### **The human factor approach and human error** (see chapter 5)

The human factor approach is used as a specification of the systems approach, because the presence of people in the system increases the level of complexity tremendously. The human factor approach is about expanding our knowledge of human capabilities and applying it to the design of technology. The

goal of the human factor approach is to optimise the fit between technology and people on five levels: the physical, the psychological / cognitive, the team, the organisational, and the political level. The human factor approach can be used to gain insight into the system, because it shows the human factor requirements that should be met by a technology.

The human factor view on human error sees human error as a symptom of a problem deeper inside the system. Well-intentioned people are compromised in their pursuit of success, because of imperfect features of the system they have to work in (Dekker, 2006; Woods & Cook, 1999). Rather than concluding with blaming a person, one can learn from finding the system failure. Errors are made by everyone, not only by 'bad apples' and errors tend to recur: patterns can be found when looking at errors on a system level. Applying a system approach can prevent errors in the future.

Specific tensions in the acute care system concerning errors are about:

- superhuman culture in health care
- educational levels, functional independence, and scientific acting
- error awareness and feedback from the system

The differences between the fields of acute care, aviation, and anaesthesiology are large, but lessons can be learned. The anaesthesiology case showed an example of the critical incident technique. Cooper et al. (1978) only included incidents that were preventable: the fact that very often in health care, incidents are not preventable due to the high uncertainty, is important. From the ASRS case, it becomes clear that the policy framework for a reporting system is complex. Main 'ingredients' for an error safety reporting system, based on ASRS are: confidentiality, voluntary participation, non-punitive system, processing organisation must be independent, analysis of reports by experts is necessary, and dissemination of findings in different ways is necessary. It is also important that the policies 'fit in' with already present laws, regulations, and other regulating bodies.

#### **Quality of care** (see chapter 6)

Quality of acute care is multifaceted. This makes quality difficult to measure. A very important aspect of quality is that every part of quality is being influenced and determined by different levels of the human-tech ladder. Quality problems thus need to be tackled with a systems approach: at different levels at the same time. The indicators designed by the RIVM for the IGZ are shallow in the sense that they only deal with the operational level and do not consider multiple aspects and levels of quality of care.

#### **The roadmap for acute care system innovation** (see chapter 7)

The roadmap can be used as a guiding principle for the acute care system. These are the main aspects:

- People need to be convinced that the human factor approach is useful and is appropriate for the acute care system
- The human factor approach needs to be adopted
- An error reporting system needs to be developed, using the human-tech ladder as a guide
- The error reporting system in combination with the human factor approach offer the possibility to create new innovations. These innovations are based on the findings from error analysis, and are developed into T-shaped innovations to increase their chances of success.

This way human factor error analysis can help in supporting quality improving innovation in the acute care system.

The complete approach as presented here is meant to show how to look at the acute care system and its quality on a system level, and, consequently, it is about showing where the system has flaws. Really knowing 'where it hurts' in the system, will provide the opportunity not for a bandage, a quick fix, but for a full repair.

#### **Recommendations** (see chapter 8)

On the basis of this research, the main recommendation is to research in what way the human factor approach and the roadmap can be implemented. The roadmap presented is quite theoretical, and practical details still need to be designed. There will also be flaws and/or difficulties in using the roadmap, though: it might be hard to use, to understand. Iterations and improvements of the roadmap will be necessary.

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## Abbreviations and glossary of terms

Abbreviation	English	Dutch	Further explanation
AED	automated external defibrillator	automatische externe defibrillator	Machine used to give an electric shock to people without heart failure
CPA	Central Ambulance Unit	Centrale Post Ambulance	Call centre that handles all calls to emergency number 112
	disciplinary tribunal	tuchtcollege	
GP	General Practitioner	huisarts	
HAP	General Practitioner Centre	huisartsenpost	These centres are open during nights and weekends.
IGZ	Inspectorate of Health Care	Inspectie voor de Gezondheidszorg	
NPCF	Dutch Patient Consumer Federation	Nederlandse Patienten Consumenten Federatie	
	practitioner	zorgverlener	A person with medical education, working in health care (this can be both a nurse and a doctor)
RVZ	Council for Public Health and Health Care	Raad voor de Volksgezondheid en Zorg	
	triage centre		see CPA
	triage	triage	The process of finding out what the health situation of the patient is and what care should be provided
VWS	Ministry of Public Health, Welfare, and Sports	Ministerie van Volksgezondheid, Welzijn en Sport	



# 1 Introduction

There are several signs that the acute care system in the Netherlands might not function optimal. This research focuses on ways to innovate, and thereby to improve the quality of the care delivered. In this chapter the problem is introduced. The background and context of this research are described in section 1.1. In section 1.2, the research objective is elucidated, after which in 1.3 the research questions are presented. Section 1.4 shows the information sources used for this research. Finally, section 1.5 provides an overview of the structure of this report and reading instructions for different readers of this report.

## 1.1 Background

In case of severe injury, or acute illness, medical care is needed fast. In the Netherlands, this care is provided by multiple local, both public and private organisations which make up the acute care system.

The acute care system is made up of a large web of organisations (among the actors directly involved are: general practitioners, general practitioner centres, midwives, emergency departments of hospitals, ambulance services, trauma centres, and triage centres (Nederlandse Patiënten Consumenten Federatie, 2006)).

The acute care system is very large, which complicates cooperation and coordination. To provide insight into the size of the system: currently, there are 34 ambulance organisations, with a total of 198 ambulance stations and 685 ambulance cars. Together, they drove:

- 428,257 A1-rides (arrival norm 15 minutes) in 2007
- 208,133 A2-rides (arrival norm 30 minutes) in 2007

This is almost 1750 emergency rides a day and it means that about 4% of the people in the Netherlands have an emergency ride per annum. There is a double arrival times norm: the norms (15 or 30 minutes) should be met in 95% of cases.

The central units or ambulance dispatch centres (CPA, Centrale Post Ambulance, of which there are 24 in the Netherlands), or triage centres, handle all calls to 112, the national emergency number. They need to triage all patients over the phone: this means they have to find out what has happened, what the health situation of the patient is (without being there and seeing the patient), and have to decide what kind of care and/or transport are needed. The CPA triage centres annually get 5.3 million calls, of which 3.4 million (64%) are 'non-serious calls', which include prank (false) calls, non-urgent calls, and trouser pocket calls ('broekzakbellers' in Dutch) (112.nl, 2008). This equals more than 14.500 calls a day: over 600 calls on average for every CPA, of which about 390 are 'non-serious calls'. In about one-third of the serious calls, an ambulance is sent on its way to collect the patient. In other cases, patients are referred to their general practitioner or to a general practitioner centre.

Because of the complexity of the care they provide and the multiform structure of the system, it is not easy to get insight into the quality of the system. Some indicators for quality are fairly easy to measure, such as the compliance with the arrival norms of ambulance cars: in remote areas the norm is only met in 70 to 80% of cases (Malschaert, 2008). Arrival time is only one of the factors influencing health outcome, though, so it cannot be used as a direct indicator for quality (Malschaert, 2008). Quality of other parts of the work of the acute care system, such as the quality of triage, are even harder to grasp.

The Inspectie voor de Gezondheidszorg (Inspectorate of Health Care, hereinafter called IGZ) published a report in 2004 on acute care, in which they base their findings solely on questionnaires and interviews (Inspectie voor de Gezondheidszorg, 2004). The Raad voor de Volksgezondheid en Zorg (Council for Public Health and Health Care, hereinafter called RVZ) concluded in 2003 that there is a lack of quality norms for acute care in the Netherlands and that this is the most urgent problem for this sector. The first and foremost cause for this is the lack of data, according to the RVZ: "First of all, there is no uniform registration and registration has not been automated yet. [...] In order to pronounce upon the quality of the chain of acute care, reliable, continuous data collection is necessary by care providers." (Raad voor de Volksgezondheid en Zorg, 2003) In the end, it is not about quality

measurement itself, and definitely not about the quality of the quality measurement, but about quality improvement. Quality measurement is useful though, either as a starting point – to see what should improve – or as a means of feedback: is the quality high (enough)?

Recently, a report has been published on performance indicators for the acute care system, which aimed to find indicators that can “potentially reveal which part(s) of the chain present(s) the highest risk in terms of poor quality and a lack of safety” and can be used by the IGZ to fulfil their supervisory tasks (Rijksinstituut voor Volksgezondheid en Milieu, 2009). The main finding, besides the set of indicators itself, is that important information for measurement of these indicators is lacking: there are almost no registration systems that allow for the necessary information to be collected. The report concludes: “Only when the registration systems are improved will it be possible to compile the data needed for calculating the indicators and thereby determine their quality.” (Rijksinstituut voor Volksgezondheid en Milieu, 2009)

Also important for the success of the use of these indicators is: what will be done with the information that is being collected? Dekker (2006) suggests that this kind of aggregated information (imagine average response times of all A1 ambulance rides, or the percentage of calls that was answered by a CPA within 30 seconds) might not be as useful as we think. For what can we do with this information? It is possible to conclude something about the whole system, although averages and percentages do not provide a lot of information about the quality in single cases, and thus might not offer indications on where the problem lies. If the goal is to improve the system, other information is needed on a more specific level. We need to understand the underlying mechanisms that define system behaviour and that possibly trigger mistakes with the people working in the system.

Those people working in the system make the system difficult to grasp, but it is also the only way it can function: people are, unlike machines, able to act upon many different situations very flexibly. This offers a chance of saving lives, but also of making mistakes, since knowledge will always be limited and these people need to act fast. The human part of the system is therefore very important when looking at quality: it is the key to improving quality, but it might be the most difficult part to understand and to change.

To summarise: the acute care system is complex. It is a large, safety-critical system in which people have to act fast and correct. Apart from qualitative, non-generalisable statements, not very much is known about the quality of acute care in the Netherlands. So, how can we gain knowledge about the quality of acute care and the acute care system? And what can we do to improve the system, including the behaviour of the people working in the system?

## **1.2 Research objective**

The goal of this research is to gain insight into the functioning of the acute care system in the Netherlands, with a first exploration in the field of error analysis as a means to find points for improvement. In other words: by looking at the system in a holistic way, and looking at errors occurring in acute care, this research is about understanding how the system works, and what could be changed, to improve the quality of acute care.

Looking at the system in a holistic way is done using systems thinking. Systems thinking differs from common other research approaches, in the sense that: it looks at multiple actors, instead of only covering the goals of the client or problem owner; it looks at different criteria – rather than looking only at the financial aspect of a problem, it tries to cover multiple other criteria (such as quality of care, or time investment); and finally, it aims to look at more than a subsystem: when looking at complex problems, systems thinking tries to focus on interactions within a system rather than on the parts of it, which provides insight into external influences and system behaviour. This will further be elaborated in section 2.1.

This research leads up to a ‘roadmap’ that aims to offer a method for using error analysis for system innovation. The goal of the roadmap is to use knowledge about the system to create and support innovations that improve the quality of the acute care system. The roadmap is not a step-by-step guide, but rather aims to show a way of advancing the acute care system efficiently (aiming at those places where things go wrong right now) and effectively (with the right result).

The methodological approach taken in this research, especially including the human factor approach, wants to offer a new way of looking at quality and innovation of health care systems. In essence, this research is a conceptualisation of the problems within the acute care system, and provides a concept for system innovation that deals with analysing errors in order to create suitable innovations. The scientific research goal is to see whether this approach could contribute to improvement of the quality of the acute care system.

The ministerie van Volksgezondheid, Welzijn en Sport (ministry of Public Health, Welfare and Sports, hereinafter called VWS) is responsible for acute care, as is stated on their website (direct translation from (Ministerie van Volksgezondheid Welzijn en Sport)):

*“The minister of VWS is responsible for accessible and affordable primary health care [of which acute care is a part] of sufficient quality.”*

The Ministry of Health is able to initiate changes in order to improve the acute care system and therefore will be seen as problem owner.

### 1.3 Research questions

The main question of this research is:

In what way can human factor error analysis help in supporting quality improving innovation in the acute care system?

In this main question, four main topics can be distinguished: acute care, innovation, the human factor, and quality. These topics have their own sub questions, that together lead to an answer to the main question:

#### Acute care (ch.2)

- SQ1: What is acute care?
- SQ2: What is the acute care system?

#### Innovation (ch.4)

- SQ3: What is innovation?
- SQ4: Why do you need innovation?
- SQ5: What are the deficiencies of the acute care system that hamper innovation?
- SQ6: What are requirements for an innovation-supporting acute care system?

#### Human factor (ch.5)

- SQ7: What is the human factor approach?
- SQ8: How can the human factor approach be used to gain insight into the functioning and quality of the system?
- SQ9: What is human error?
- SQ10: How can you analyse and handle human error?
- SQ11: What can be learned from anaesthesiology and air traffic control about incorporating the human factor approach?

#### Quality (ch.6 and 7)

- SQ12: What is quality of acute care?
- SQ13: What is needed to change the acute care system into an innovation-supporting system that supports quality improvement?

And finally, the question related to the scientific goal of this research:

- SQ14: Can this approach lead to innovation that improves the quality of the acute care system?

### 1.4 Research method: information sources used

For this research, methods will be used that are based on systems theory. These methods will be explained in chapter 3. This section will elucidate the information sources used for this research. The research is based on different sources, mostly on literature. The main sources used are:

- scientific articles and books
- reports

- legislation, jurisprudence, and verdicts of the disciplinary tribunal (tuchtcollege)
- interviews

Below, these sources and their selection will be described more in depth.

### ***Scientific articles and books***

This type of sources have been used the most for this research, because the basis of this research lies in setting up a scientifically sound framework for the roadmap. The following topics have been identified as important on the basis of the research questions:

- acute care
- systems thinking
- systems engineering and policy analysis
- innovation
- human factor
- human error
- quality of care

The selection of articles and books is based, besides on availability and appropriateness, on recency: for most topics, it was possible to select sources that were less than ten years old, to prevent the knowledge from being outmoded.

### ***Reports***

Reports by the RVZ, IGZ, RIVM, and NPCF (Nederlandse Patiënten Consumenten Federatie: Dutch Patient Consumer Federation) have been used for this research. Only reports from 2003 or later have been used. The reports offered some insight into the functioning of the system from different perspectives, although they were not very detailed and often very diplomatic.

### ***Legislation, jurisprudence, and verdicts of the disciplinary tribunal (tuchtcollege)***

Dutch legislation that influences the acute care system has been reviewed. Verdicts of several cases of the disciplinary tribunal of health care have been reviewed and used as input for this research.

### ***Interviews***

Interviews have been conducted with several experts from the field of acute care, and an expert on aviation and human error. In appendix A, a list of all interviews has been drawn up, with information on the findings.

## **1.5 Report structure and reading instructions**

Chapter 1 provides an introduction to this report and the background of the research. Chapter 2 introduces the acute care system from different perspectives. The methodology of this research is described extensively in chapter 3.

In chapter 4, innovation in the public sector is discussed: what is it? Is it necessary? And what can help foster innovation within the acute care system? Chapter 5 uses the human factor approach and focuses on human error and how to analyse it. Also, two cases are described, from the fields of anaesthesiology and aviation. In chapter 6, the research elaborates on the definition and characteristics of quality to show what the complexity of quality is, and to show what aspects on quality can be focused on to improve.

In chapter 7, all of the information and knowledge gathered in the previous chapters is compiled to create a roadmap for system innovation. It focuses on the requirements for a system that supports and fosters innovation, and already adds an innovation in the form of an error reporting system. This system innovation can be used to find more opportunities for innovation.

Chapter 8 contains the conclusions and recommendations from this research. A discussion on the future of the acute care system in the Netherlands and a reflection on this research are laid down in chapter 9. Finally, in chapter 10 options for further research are presented.

### ***Reading instructions***

This report will be read by people from different backgrounds. Since this report provides one 'story', so to speak, it is advised to read it completely and in order. However, the following advice may be useful:

*No time:* please read the summary, and use the references in the summary to get more in depth information on the topics you are interested in.

*With knowledge of systems thinking and policy analysis:* you may omit sections 3.1 and 3.2, although section 3.2 also provides information on the specific application of policy analysis methods on the acute care system.



## 2 What is the acute care system?

This chapter is a brief introduction to the Dutch acute care system. Different aspects are covered and explained to gain more insight into the system and its complexity. The information gathered in this chapter forms the practical basis for the research in the chapters 4 to 7 (the theoretical basis is provided in chapter 3).

First of all, in section 2.1 the acute care will be defined and delineated. Section 2.2 and 2.3 describe the phases of the acute care process and the different 'routes' patients can take through the system. In section 2.4, the communication between different organisations is discussed. The people working in the acute care system, and their education and training are discussed in 2.5. Sections 2.6 and 2.7 deal with guidelines, protocols, norms, and laws on the acute care system. The administrative system behind the acute care system is a complex 'network': this network is shown in section 2.8. The norms the IGZ uses for its quality measurement are explained in section 2.9. In section 2.10, disciplinary rules and the way the disciplinary council works are elucidated. In section 2.11, a case is being described that will return in other chapters of this report. Finally, section 2.12 draws conclusions: what is the acute care system?

### 2.1 Definition of acute care

Acute care is a term with multiple, mostly non-practical definitions. Since this research aims to research the 'acute care system', it is important to define acute care to set boundaries.

Acute care is part of health care. There are varied definitions of health care, but for the purpose of this research, the following definition is adopted, because from this definition, the main goal of health care becomes clear, which can help in judging whether the system is functioning properly at the moment: "[Health care is] composed of health care systems and actions taken within them designed to improve health or well-being." (Campbell, Roland, & Buetow, 2000) Although the systems are *designed* this way, are they also *used* for that purpose? Should all demand for acute care be considered part of the acute care system, or only the medically just demand for acute care (in case of emergencies)? In the first case, arguing from a patient's perspective, the acute care system is larger than in the second, medical perspective. The medical perspective is linked to the goal that is set in the definition of acute care as the Raad voor de Volksgezondheid en Zorg (Council for Public Health and Health Care, hereinafter called RVZ) presents it:

*"De keten van activiteiten die erop is gericht zo spoedig mogelijk, maar in ieder geval binnen enkele minuten tot enkele uren, zorg te verlenen om overlijden of irreversibele gezondheidsschade als gevolg van een acute levensbedreigende aandoening of een ongeval te voorkomen."* (Raad voor de Volksgezondheid en Zorg, 2003)

*"The chain of actions aimed at providing care as soon as possible, but in any case within a matter of minutes to a few hours, to prevent death or irreversible health damage as a consequence of an acute life-threatening disorder or an accident."*

#### **Theory and practice**

The definition as stated above fits the formal, medical goal of the acute care system. When one ignores the medically unjust demand for acute care (no medical reason), though, one also leaves out real-life inefficiencies of the acute care system: in practice, care providers select and treat patients differently, causing non-acute patients to enter the system (Raad voor de Volksgezondheid en Zorg, 2003). Besides that, there is an increasing number of self referrals that enter the system (Inspectie voor de Gezondheidszorg, 2004).

When evaluating the acute care system, it should be decided whether it is being judged on the 'net output', so the number of people treated, for example, or the efficiency and effectiveness regarding the main medical goal: did the true acute care patients receive care of good quality?

### **Trauma care**

Trauma care is a term used solely for dealing with people who suffered injury (trauma) due to an accident. Trauma care is thus part of acute care.

### **Somatic acute care**

Within care a distinction can be made between somatic and mental health care. Since in the Netherlands, the systems for somatic and mental health care are separate, this research will not cover acute mental health care.

## **2.2 The acute care process in phases**

The acute care system is often referred to as an 'acute care chain'. This is because the work carried out by organisations in this chain is successive in time. The RVZ identified the following four phases (Raad voor de Volksgezondheid en Zorg, 2003):

- *Call*: there is an acute situation, which is announced by the patient, onlookers, or the general practitioner through a phone call to 112.
- *Presence of care providers on-site*: the Central Unit (CPA) for ambulance transport directs care providers to the location.
- *Transport*: the patient is transported by ambulance car or helicopter to a place where the necessary care can be provided.
- *Care facility*: the patient arrived at a care facility, either the emergency department or intensive care department of a hospital, or a specialised trauma centre.

Of course, this is not always the 'route' patients take through the acute care chain. Section 2.3 shows other patient flows in a model.

## **2.3 Patient flow model**

The acute care system is often called a 'chain' of actions or of organisations. This leads one to suspect that it is a straight chain. This is not the case: patients can take multiple routes through the system, in which they will receive treatment if needed, but it might take them a few 'wrong' stops before arriving at the 'right' location. On the next page, all possible flows are depicted (see figure 2.1) with the dark blue circles depicting decisions.

On the left side, patients have an accident or fall ill. They (or onlookers) need to decide where to go or whether to call 112 (the central unit, CPA). At every 'station' the patient arrives, there is the possibility of being sent home, because the medical staff does not consider the ailment serious (enough). The general practitioner can consider the ailment serious enough to refer to the hospital. This takes place either by sending the patient to the hospital on his own, or by calling an ambulance. In this case, when the general practitioner calls the central unit for an ambulance, it will certainly come – there is no chance of the request being rejected.

It is important to note that not all theoretically possible flows are in the model, only the practically possible: for example, if a patient first went to the general practitioner or the HAP (huisartsenpost: general practitioners centre) and got referred to the hospital, hospital staff will not send that same patient back to the general practitioner, even if treatment there would have been suitable. Another example: after someone has been brought into hospital by an ambulance car, they will not refer that patient to the general practitioner anymore.

The decision nodes are crucial for the success of the acute care system. In each node, people – the patient, onlookers (both often without medical knowledge), the general practitioner (with or without knowledge of the patients' medical background), the emergency department personnel (possibly under stress because of the large amount of patients, for example), the triage nurse (on the phone, without being able to see the patient), and the ambulance nurse (who might not have knowledge of rare conditions, see section 2.5) – have to make decisions that can make a difference: if lives are at stake, these decisions (or even postponing those decisions) can have grave consequences.



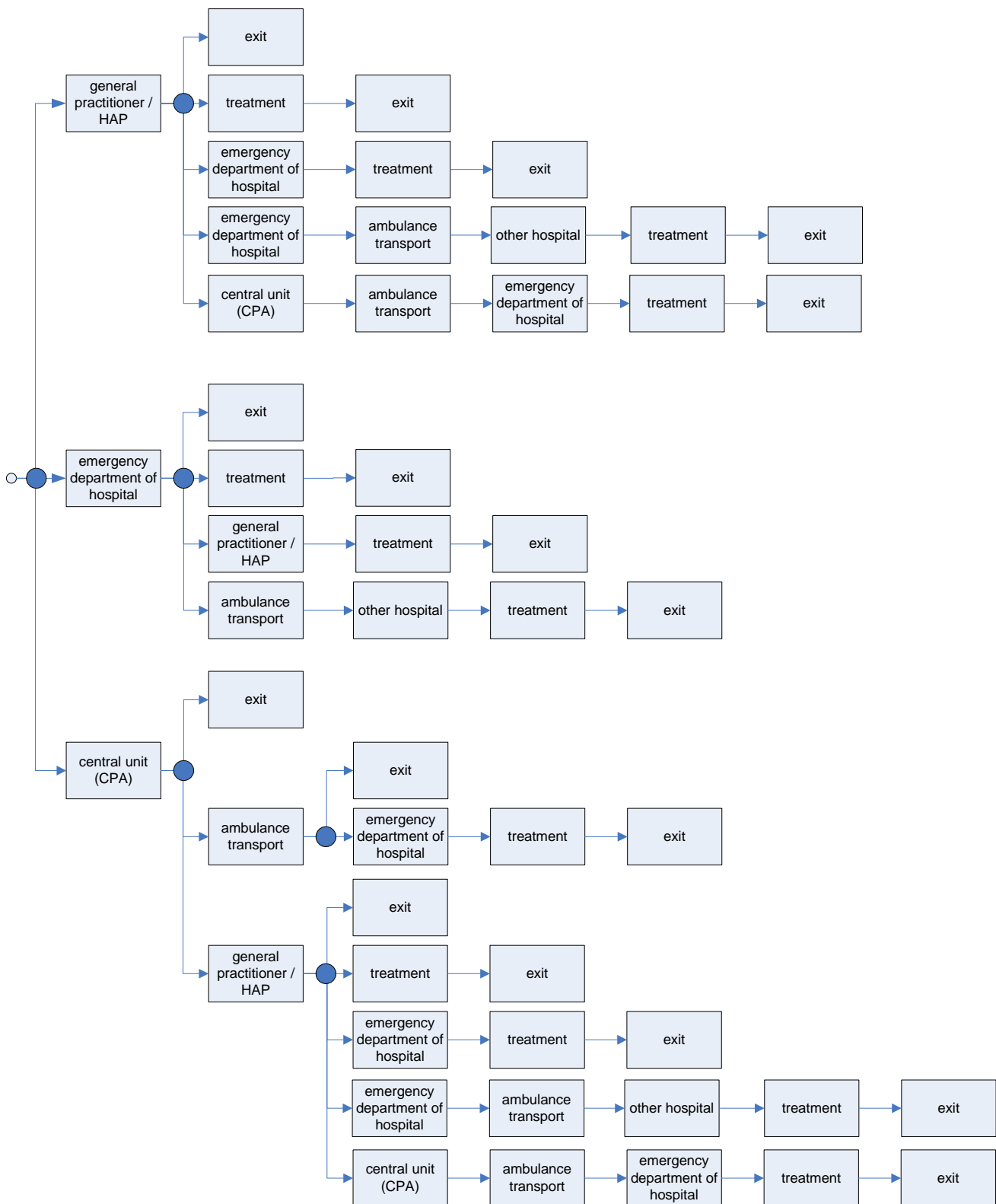


Figure 2.1: Patient flow model with decision nodes

## 2.4 System communication model

A second model shows the acute care system on the communication level. It shows only regular acute care; GHOR ('Geneeskundige Hulp bij Ongevallen en Rampen', medical aid in accidents and disasters) activities, during large accidents and disasters, are not included, since in that case, also the municipality, police, and fire brigade are involved on a large scale, and those situations form not the main focus of this research. In the diagram (see figure 2.2) the main four organisation types can be seen. The communication between these parties is represented by arrows. An intermittent line stands for non-permanent communication, which can be hard to establish for general practitioners and hospitals (Inspectie voor de Gezondheidszorg, 2004). The solid arrows represent a permanent communication facility, such as the C2000 system: this is the communication system for all emergency services, such as ambulances, police, and fire brigade.

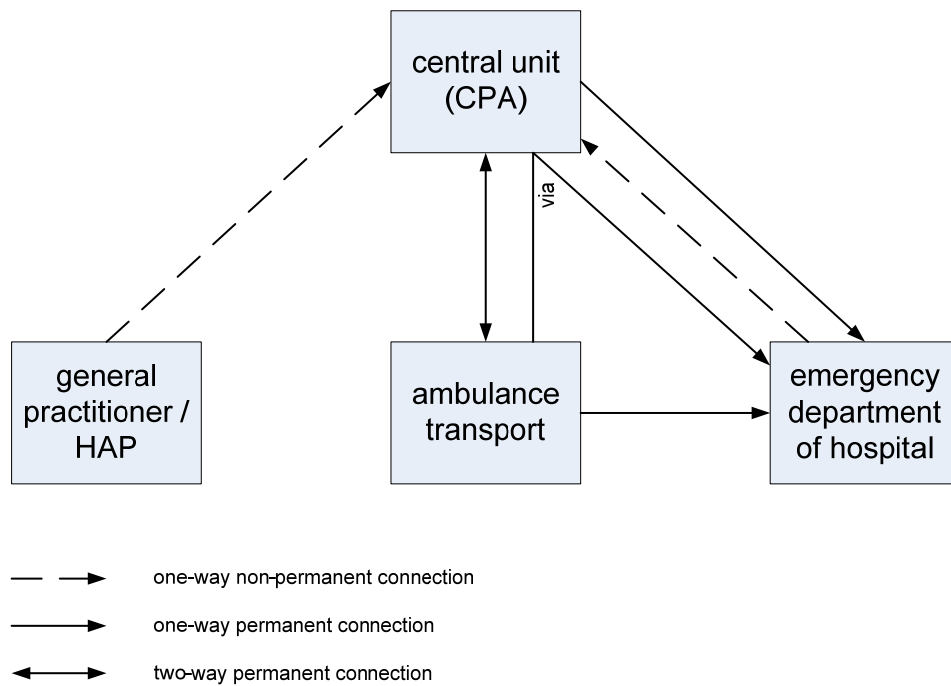


Figure 2.2: System communication model

The C2000 system has been in place for a number of years now, but it does not function optimally: the capacity of the masts is too low in some places, causing tunnels and remote areas to be out of range, as well as high buildings, and underground parking lots, for example. The network also gets congested in case of a large accident, because of the large amount of communication between all emergency services. Currently, these problems are researched by an expert group (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2009, 16 September).

Since technical communication problems seem to be abundant, it can be useful to look at the whole system: this can help in identifying the causes of the problems, and can show what effects changes to the system might have. Such a system approach is explained in chapter 3.

## 2.5 People working in the acute care system

The acute care system is the working environment of many people. Most of them are nurses, trained additionally for the job they are doing (ambulance nurses, triage nurses at ambulance dispatch centres, etcetera). There are also people without medical education, such as the ambulance car drivers. They need to have had specialised training, though, so they are also able to help in providing some emergency care. In the Netherlands, there are 3700 nurses and drivers working in the acute care system (Ambulance Zorg Nederland, 2009). The doctors in the system are the general practitioners, first aid doctors at the emergency rooms of hospitals, and trauma doctors who are part of a trauma team that is dispatched to large accidents.

### ***Education and training of nurses and drivers***

Nurses in the acute care system are obliged to have a nursing degree (HBO (professional education) or MBO (vocational education) with certain additional requirements), they need to be a registered nurse (see section 2.7) and they have to have received additional specialised training. Before they can start their specialised training they already need to be employed with an ambulance service. (Stichting Opleidingen Scholing Ambulancehulpverlening, 2009) Possible negative implications of the educational levels of the practitioners concerning acting in line with state of the art knowledge, are discussed in section 5.4.

The ambulance car drivers need to have a first aid diploma (EHBO-diploma), and a driver's license. Besides that, they already need to be employed with an ambulance service.

The ambulance nurses and drivers, and the triage nurses are educated by the Academie voor Ambulancezorg (Academy for Ambulance Care). They are educated in about 400 hours for ambulance nurses, 550 hours for ambulance car drivers, and 300 hours for triage nurses (Stichting Opleidingen Scholing Ambulancehulpverlening, 2009). Brush up courses on different topics are provided frequently, and are obligatory: every five years, re-registration is necessary (Registratie en Informatie Beroepsbeoefenaren in de Zorg, 2009). For re-registration, all courses should be followed and a practical exam has to be passed. (Stichting Opleidingen Scholing Ambulancehulpverlening, 2009)

### ***Experience***

For anyone working in a safety-critical system, it is important to know how to handle emergencies, because they are different from routine work and they put a lot of pressure on people. In most safety-critical systems, this is solved by training: for example, aircraft pilots are obliged to participate in simulations of emergencies, which are videotaped and evaluated afterwards (in 't Veld, 2009). This helps those pilots learn in a safe environment, to prepare for very rare emergencies.

In acute care, this is different: there is almost no routine, only emergencies (the only routine work being administrative work and planned, non-acute B-rides for ambulances). There are simulations, or role-plays, in acute care, and these are mainly simulations of large disasters (Inspectie Openbare Orde en Veiligheid, 2009). This does seem logical, since large disasters are very rare. But also for the 'regular' emergencies, it is important to 'stay in shape': in some rural areas, such as the eastern part of the province of Groningen and the centre of the province of Zeeland (Walcheren), the number of emergencies is low (Kutterink, 9 October 2009), for example due to low population density, but also because there is less traffic. The ambulance nurses and drivers working in those areas get a very low number of emergencies, which could result in a lower quality, since they are less experienced.

### ***Experience versus travelling time***

The same regions in Zeeland and Groningen also suffer from problems with ambulance arrival times (Dagblad van het Noorden, 29 September 2009; Kutterink, 9 October 2009). The causes for these problems are not easy to pinpoint. One major reason could be the geographical dispersion of the ambulance dispatch centres: if the spread is too wide, the travelling time becomes too long and quality of care may suffer. The advantage is, though, that the ambulance nurses and drivers get to handle more emergencies, and the quality of care may increase. The RIVM (2003) conducted research on the topic of geographical dispersion and concluded that of the 8.2% of ambulance A1 rides in which the norm was exceeded, at the most 20% were due to the geographical dispersion of the ambulance dispatch centres. The uncertainty of this number is caused by a lack of registration (the circumstances that caused the exceeding are not reported). (Rijksinstituut voor Volksgezondheid en Milieu, 2003) Still, the geographical dispersion and the number of emergencies the ambulance workers experience are conflicting goals; there is a tension between these goals. Is there an optimum, and are we able to find that optimum? This will be elaborated upon in section 3.2.

### ***They are only human***

People working in the acute care system have difficult jobs. The circumstances are far from perfect, people have to work under stress, because most of the work concerns emergencies with large risks. Therefore, it is beneficial if all other, 'non-human' parts of the acute care system are attuned to the needs of these people working in the system. This is further explained in section 3.3.

## 2.6 Protocols and guidelines in acute care

The field of acute care is filled with protocols and guidelines that are designed to aid decision making in different (parts of the) processes. Some examples:

- medical guidelines concerning disorders or illnesses (Kwaliteitsinstituut voor de Gezondheidszorg CBO, 2009)
- medical guidelines concerning actions, such as administering medication, or intubation, etc.
- guidelines concerning triage, focusing on both the practical side of triage, and the organisational requirements (Lectoraat Acute Intensieve Zorg, 2008)
- protocols, or norms, on the way quality should be managed and organisations should work. An example is provided below. (Stichting Harmonisatie Kwaliteitsbeoordeling in de Zorgsector, 2002)

### ***HKZ norm example: intake and indication in ambulance care***

The certification plans of HKZ have a fixed number of sections, of which the first three contain norms for the operational work of a certain sector. In the case of ambulance care, the first section is on intake and indication (Stichting Harmonisatie Kwaliteitsbeoordeling in de Zorgsector, 2002). Some examples of the norms mentioned in that section (direct translation):

- Depending on the situation, the ambulance team should be on the spot within the determined period after the alert arrived at the CPA. (1.1.1)
- Planning of staff and materials is in accordance with the requirements of the dispersion plan. (1.2.2)
- The ambulance team assesses the demand for care and, if necessary, requests more information from the CPA. (1.3.2)
- The ambulance team checks the car, key management, crew, and equipment. (1.4.1)
- Communication during the ride and during any contact with the hospital, general practitioner, and other people involved, is according to current agreements. (1.4.4)
- Concerning the permission of the patient, one acts under the legal provisions of the WGBO. (1.5.1)

It can be concluded that these norms are combinations of other guidelines: all details are in other documents.

### ***Juggling all guides***

This section shows that there are many protocols, norms, and guidelines for different parts of the acute care system. They might be conflicting, and they are probably quite complex to master all: it might be difficult to have all these 'guides' in your active memory at the same time to be able to handle accordingly. The human factor in juggling this kind of knowledge will be treated in section 5.3.

Besides all these guidelines and protocols, there are laws: these will be highlighted in 2.7. The IGZ has its own indicators to see whether in practice, the policies on acute care are working as intended. This will be explained in 2.9.

## 2.7 Laws

Many laws influence the work within the acute care system. Below, a couple of laws directly related to acute care are listed:

- **Kwaliteitswet zorginstellingen:** the quality of health care institutions act makes health care institutions responsible for the quality of their work (see appendix B for the central article 2 of this act), and it obliges organisations to implement quality control systems, and obliges them to give account of their performance annually to the minister of VWS
- **Wet ambulancevervoer (WAV):** the ambulance transport act will be replaced in 2011 by the wet ambulancezorg (WAZ), the ambulance care act. They have a large impact on the acute care system, and because of that are discussed more elaborate below.
- **Wet Geneeskundige Hulp bij Ongevallen en Rampen (GHOR):** this act concerns Medical Aid in Accidents and Disasters. This act is unusual in the field of acute care, since it puts municipalities in charge of the organisation and coordination of medical aid during large accidents and disasters. This act will be elaborated upon below.
- **Wet op de beroepen in de individuele gezondheidszorg (BIG):** the act on professions in individual health care handles protected titles, provides for registration of people with such a title in a register, and prescribes the actions that are restricted to these registered people

(voorbehouden handelingen). Because of this act, ambulance nurses have functional independence: they are allowed to perform certain risky medical actions without the consent of a doctor. This will be elaborated upon in section 5.4.2.

### ***Wet Ambulancevervoer (Ambulance Transport Act)***

This act regulates the transport of sick persons and accident victims and their companions with ambulance cars. The following bullet points are the main points of this act:

- The Provincial Executive (*Gedeputeerde Staten*) decides upon the minimum and maximum number of ambulance cars in a region (these regions refer to the division of the Netherlands in 24 regions as mentioned in the Firefighters Act (Brandweerwet 1985) and the appendix of the Police Act (Politiewet 1993)), and decides what the distribution over the region should be. On this matter, the IGZ is allowed to advise, and the Minister can draw up policy documents about it. (art. 4)
- The Central Unit coordinates all requests for care: there it is decided whether ambulance transport is necessary and, if so, who will execute the transport and in what way. (art. 7)
- The Provincial Executive has to grant a license for executing ambulance transport. The license can only be withheld if the number of licenses would exceed the size of the demand, or if it is expected that there will be no compliance with the decisions of the Central Unit. (art. 10)
- In case the number of ambulances is below the minimum, the municipality or municipalities in the region are obliged to provide for the necessary ambulance transport. (art. 15)

### ***Wet Ambulancezorg (Ambulance Care Act)***

In 2011, this act will replace the WAV. Below, the main changes are described:

- The concept of ambulance care is introduced. Its definition: “ambulancezorg: zorg, erop gericht een zieke of gewonde ter zake van zijn aandoening of letsel hulp te verlenen en per ambulance te vervoeren” – “ambulance care: care, aimed at providing help and transport by ambulance to a sick or injured person for his disorder or injury”. (art. 1)
- The Minister gets the tasks the Provincial Executive had in art. 4 of the WAV. (art. 2 and 3)
- From 2011 onwards, in every region only one legal body gets a license for executing ambulance transport. (art. 3)
- Every four years the Minister issues a Ministerial regulation in which he lays down requirements with ambulance care providers must meet. (art. 4, par. 1 and 2)
- The GHOR office is obliged to set requirements for the central unit (CPA) of the ambulance care provider. These requirements should also cover a good daily cooperation with police and fire brigade. (art. 4, par. 3)
- When the Minister proposes to change the requirements, he must ask for advice with the health insurers in the region and the GHOR office. When their advice is collective and univocal, the Minister has to adopt it, unless ponderous interests oppose it. (art. 4, par. 4)
- An ambulance care provider that wants to apply for a license has to present a plan on how they will meet the requirements. (art. 4, par. 5)
- Health care insurance companies that are active in the region will be asked for their view and a ‘consequential advice’ on the plans of an ambulance care provider applying for a license. (art. 5, par. 1)

### ***Wet GHOR (Medical Aid in Accidents and Disasters Act)***

This act comprises rules on the organisation and execution of medical aid in large accidents and disasters, and the corresponding preparations.

- The mayor and aldermen of a municipality are in charge of medical care in case of large accidents and disasters. They are also responsible for setting up agreements necessary for efficient medical care. (art. 2)
- After the enforcement of the WAZ, the mayor is authorized to instruct the Regional Ambulance Service if necessary when public order is threatened. (art. 2a)
- The mayors and aldermen of municipalities united in one region are obliged to make collective arrangements about medical care and its preparation to realize efficient and coordinated medical care. (art. 3)
- When interregional disasters occur, the mayor(s) can turn to the Royal Commissioner of that province. If the disaster is interprovincial, the Royal Commissioner can in turn go to the Minister of Internal Affairs, who will then coordinate all actions together with the Royal Commissioners of all provinces involved. (art. 17 and 18)

The acts described more elaborate above show that many actors are involved in the acute care system: they do not seem part of it – the mayor, the provincial executive, etcetera – but they have great influence on the political level of the system, and with that, also on the work carried out in the lower levels. This can be analysed more thoroughly using the human factor approach, as will be elucidated in section 3.3.

## 2.8 The administrative system behind the acute care system

The administrative layers of the acute care system are shown in figure 2.3. As can be seen, a lot of organisations are involved. The columns represent different types of organisations, while the rows show different administrative levels, ranging from national to local. The organisations are placed in this grid, according to their prevalence (the number of organisations is displayed to the right of each box). Most of the organisations are public, but the transport organisations for example are almost all private.

In 2011, this system will change, because of the enforcement of the new ambulance care act, the WAV, as described in section 2.7. Then some parts of the system will change, but the details are outside the scope of this research. The main point here is that the system is steered and influenced by multiple organisations, on different levels.

### Administrative system (before 2011)

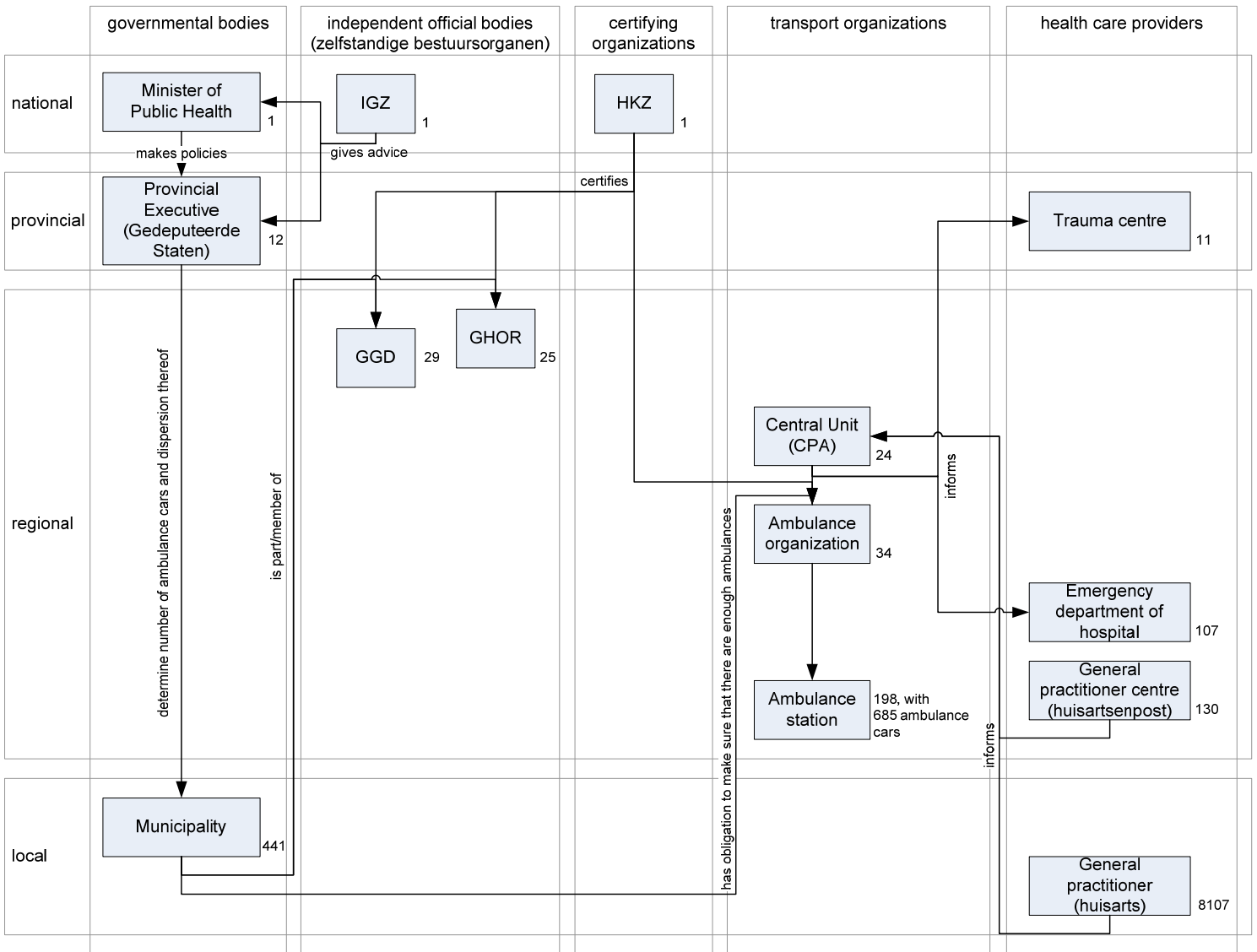


Figure 2.3: Administrative system model

## 2.9 IGZ norms and quality measurement with indicators

The inspectorate wants to improve public health by maintaining the quality of care. They do this by comparing practice with the policies and laws in place, and advise the Minister of VWS. The IGZ “researches and judges impartial, professional, precise, and independent of political leanings or the prevalent health care system.” (Inspectie voor de Gezondheidszorg, 2009)

To judge the quality of care, the IGZ uses laws and regulations, but also norms and guidelines from the field. For the past years, the IGZ has been working on indicators to measure quality of care. The hospital quality indicators were first implemented. In ambulance care, there is some experience with indicators such as arrival times, but not with outcome indicators (van Ankum, 2009). Recently, a report by the RIVM, commissioned by the IGZ, was published on indicators for the field of acute care.

The goal of that research was to “potentially reveal which part(s) of the chain present(s) the highest risk in terms of poor quality and a lack of safety” and can be used by the IGZ to fulfil their supervisory tasks (Rijksinstituut voor Volksgezondheid en Milieu, 2009). The complete list of indicators is included in appendix C (in Dutch).

These indicators as proposed by the RIVM are all about operations: they only cover the work in the field. Quality does not only emerge from the actions performed in the field, though: it is a synthesis of actions on multiple levels. Therefore, it is questionable whether these indicators cover all aspects of quality. The multi-faceted character of quality will further be discussed in chapter 6.

The main finding, besides the set of indicators itself, is that important information for measurement of these indicators is lacking and the RIVM concludes that registration systems are a first priority (Rijksinstituut voor Volksgezondheid en Milieu, 2009).

## 2.10 Disciplinary rules (tuchtrecht) and the disciplinary council

The disciplinary rules for health care in the Netherlands are built around two basic norms:

- To act (or omitting to act) conflicting with the care that the registered medical care provider should provide to the patient. Examples are: wrong diagnoses, prescribing wrong medication, but also: not providing information about treatment, violating professional confidentiality, etcetera.
- Any other act (or failure to act) conflicting with the importance of a good practice of individual health care. This rule is more general and is meant to safeguard other parts of health care not directly related to patients.

These norms together form a basis for disciplining practitioners registered in the BIG register. There are five regional disciplinary councils and one central council for appeal cases (hoger beroep). Patients, but also family members, the IGZ, the direct supervisor of the practitioner, colleagues (that saw their own work threatened by the mistake of the practitioner), or the employer of the practitioner, can file a complaint with the disciplinary council. (Tuchtcollege voor de Gezondheidszorg)

### ***Disciplinary measures***

The disciplinary council starts an investigation, and can pronounce the complaint either legitimate, illegitimate or non-admissible (the complaint cannot be judged by the disciplinary council, for example because compensation for damages was demanded, which is only possible through a civil law suit). When the complaint is legitimate, the practitioner can be charged with one or more of the following six measures:

- warning
- reprimand
- monetary penalty (of a maximum of € 4.500,-)
- (conditional) suspension from registration in the BIG-register (for a maximum of one year)
- partial disqualification of practising the profession (the practitioner can stay registered, but is not allowed to perform certain actions, which will be recorded in the BIG-register)
- strike-out of the registration of the practitioner in the BIG-register (the practitioner loses his title and is not allowed to use it or the rights that are associated with it)

### ***Multiple ways of reaching quality improvement?***

Disciplinary rules are set up in the first place to be able to reprimand practitioners, but using – unlike in civil law – medical experts to judge the actions of the practitioner. The broader goal behind this is the goal of improving quality: first, quality is improved, one hopes, when the failing practitioner is being reprimanded: s/he will not make that mistake again. Second, publication of disciplinary verdicts can offer other practitioners to learn from it. Finally, disciplinary rules can also be used as a means of scaring practitioners: 'if they are afraid of being punished, they will not make mistakes'. Whether these ways can actually reach the goal of quality improvement will be discussed further in chapter 5.

### ***Learning from errors***

Learning from errors can be a useful way to improve the acute care system: if one researches the error thoroughly, often many points of improvement can be found. In aviation, transport, and other infrastructures (such as drinking water), thorough research is more common: investigations in those fields result in hundreds of recommendations on different levels: they are not only about the person that erred, but also about the system surrounding the person (Dekker, 2006; Vicente, 2006). In (acute) care, this does not happen. The disciplinary council has a limited task based on the two norms described above, and thus they are not in the position to judge about other parts of the system but that particular practitioner. Learning from errors will be covered elaborately in chapter 5.

## **2.11 Case: errors in acute care**

In this section, a case is described. It is a true story in which six complaints were filed with the regional disciplinary council in Amsterdam under codes 06/252 to 06/257. The story is summarised and structured below (*Uitspraak in de zaak 06/255Vp*, 2007).

The father and partner of a man filed six complaints with the disciplinary council against several health care practitioners that were involved in the case, about 1.5 years after his death.

### ***2005***

The man was 29 years old, healthy and energetic, and rarely visited his general practitioner. In March and April 2005 he complained of tiredness. On 8 and 9 May, he stayed home from work, because of a severe headache. In spite of advice from his partner and parents, he did not visit his general practitioner. On 31 May, the man vomited at work, but again did not consult his general practitioner.

### ***June 1<sup>st</sup> 2005***

The next day, on the first of June, the man went to work. When arriving at home, he had trouble walking up the stairs to his apartment on the fourth floor: he could not coordinate his feet and he bumped into the standing steps of the staircase. He failed to finish his dinner – a pizza – which was unusual.

### ***22:45h***

At around 22:45h, while sitting on the couch with his partner, the man reached for his throat and shouted that he felt pain on that spot. He tried to get up, but fell down and shouted "This is very bad, call 112" (the emergency number). He vomited, complained about pain in the back of his head, and suffered from a stiff neck. His speech had altered, and only spoke short, stuttering sentences.

### ***22:58h***

His partner did not call 112, but decided to call the general practitioners centre (hereinafter called HAP, after 'huisartsenpost' in Dutch). After answering a couple of questions, the HAP promised to call back within a few minutes.

### ***23:10h***

The HAP did not call back, and the partner decided to call 112 at 23:10h approximately. After again answering questions, the CPA (handling all health related calls to 112) responded that first a doctor should be called in, before an ambulance could be sent. Apparently, during this phone call, the HAP called again, but the line was busy. The HAP did not call again.

### ***23:26h***

The partner again called the HAP, and spoke to a doctor, who paid a visit at around 23:50h, on the basis of the complaints of pain in the neck and vomiting.



**23:50h**

The HAP doctor decided to subject the patient only to a short anamnesis, because – as the doctor stated during the hearing – he saw that the patient was ill and he did not want the patient to have to tell the whole story again. The physical examination showed:

- the man spoke thickly ('met dubbele tong')
- he was fully conscious, with a full score of 15/15 on the Glasgow Coma Scale (GCS), which is based on three tests that focus on eye, verbal, and motor (movement) responses
- he could tell clearly about his complaints: pain in the neck, nausea, and cold sweat
- the man had a stiff neck
- he had a normal pulse (120/70)
- he had a temperature of 37 degrees centigrade
- he lost his vision of the upper right quadrant

Although this did not provide a clear image, the doctor suspected a neurological disorder, and in the first place meningitis.

By phone, the HAP doctor consulted the neurology department of a hospital in Amsterdam. Although during the hearing, the HAP doctor stated that he also considered the option of brain haemorrhage ('hersensbloeding'), to the registrar neurologist ('arts-assistent, niet in opleiding') he only spoke about a possible meningitis without fever. The registrar neurologist agreed on an urgent presentation of the patient at the emergency department of the hospital. She announced this to the emergency department, and asked the emergency department nurse (hereinafter called SEH nurse, after 'spoedeisende hulp' in Dutch) to inform her as soon as the patient arrived.

**00:25h**

The HAP doctor ordered an A1 ambulance ride.

**00:36h**

The ambulance arrived with two ambulance nurses, while the HAP doctor was waiting with the patient. The HAP doctor did not see any deterioration in the patient's situation during this period. The doctor told the ambulance nurses the working diagnosis meningitis and handed over the patient to the nurses. The nurses asked the patient whether he could walk down the stairs by himself, to which he responded that he could. The partner of the man declared during the hearing that carrying a stretcher down the narrow stairs would have been impossible. The man walked down the four flights of stairs, accompanied by one of the nurses. When the man arrived downstairs, he vomited again.

It is unclear when the HAP doctor left. He himself states that he left before the man walked down the stairs, but the partner of the man says that the HAP doctor walked down the stairs together with them and that she saw him driving away in his car.

**00:47h**

The ambulance car left for the hospital. When they almost reached the hospital, the man became restless and started to speak even more thickly.

**00:54h**

The ambulance arrives at the hospital. The consciousness of the patient has dropped to 10/15 on the GCS.

**00:57h**

The patient gets brought into the emergency department. The SEH nurse saw that the patient was in a worse condition than he had expected on the basis of the working diagnosis meningitis, and immediately involved the SEH doctor. The SEH nurse noticed a red rash on the whole body of the patient. The vital functions were:

- tachypnea, groaning breathing
- tachycard, hypertension
- 10/15 on the GCS

The ambulance nurses told that the patient had vomited a couple of times, and that the complaints had started after eating a pizza. They thought it was possible that the man was suffering from an

allergic reaction. The SEH doctor advised to give medication to treat an allergic reaction and at least to rule it out as a cause of the complaints.

The SEH nurse decided to first consult the registrar neurologist about the possible allergic reaction and to tell her that the patient had arrived. The registrar responded that the SEH doctor had to judge the possibility of an allergic reaction, and that she would be coming to the emergency department.

#### **01:10h**

The allergy medications are administered to the patient (Tavegil 2mg intravenously and dexamethason). After the medication was administered, the patient suffered from cardiac arrhythmia, which disappeared again shortly after that by itself. The red rash also disappeared. The consciousness of the patient dropped down from 7/15 to 3/15. An intensive care doctor was called in because of respiratory problems of the patient.

Just before the patient would get a muscle relaxant to be intubated to apply artificial respiration, the registrar neurologist assessed the patient's condition, to get a clear and trustworthy image of his illness. She observed:

- further loss of consciousness
- the absence of reactions to pain stimuli
- stiffness of the neck
- increasing loss of brainstem functions
- deviant foot reflexes

After the registrar neurologist heard from the patient's partner that during the evening, the patient got pain in the neck, a headache, and had to vomit, she came up with a possible diagnosis: SAH – subarachnoid haemorrhage (a bleed within the tissue around the brains). She immediately decided to do a CT-scan, without first consulting with the neurologist, her official backup. She told the partner that the situation seemed grave, and advised her to warn the patient's parents.

The CT-scan showed a large SAH, with a break of the bleed into the ventricles ('hersenkamers'), swelling of the ventricles, and signs of possible clamping of the brain: a life-threatening situation.

Because in this hospital, neurosurgical intervention was not possible, the patient was moved to another hospital by ambulance, accompanied by an anaesthesiologist. In that hospital, a drain was installed, to allow for cerebrospinal fluid to drain from the brain, but further treatment was found to be impossible. After subsequent deterioration of the patient, probably after a relapse bleed, it was decided to cease treatment, after which the patient died.

#### **2 June 2005, early morning**

The HAP doctor, before filling out his report to the general practitioner of the patient, called the first hospital to ask about the patient. He heard about what happened and about the diagnosis of SAH. In his report, the HAP doctor did not write down meningitis (his own working diagnosis), but wrote: "cerebrovascular bleeding (SAH?)".

#### **Complaints filed with the disciplinary council and other organisations**

On 30 March 2006, the father of the man filed complaints with complaint committees of general practitioner services, the CPA, the HAP, the first hospital, the emergency department of the first hospital, and directly with the HAP doctor. Before all complaints were dealt with, the father sent a letter to the disciplinary council on 22 September 2006, accompanied by six complaints, against the following practitioners:

- the registrar neurologist (06/252)
- the medical manager of the emergency department of the first hospital (06/253)
- the HAP doctor (06/254)
- the SEH nurse (06/255)
- the medical manager of the CPA (06/256)
- the (BIG-registered) person working at the HAP (who handled the phone calls) (06/257)

In the following chapters of this research, this case will be used as an example. In chapter 7, the exact complaints filed will be described, including the verdicts of the disciplinary council.

## 2.12 Conclusion

This chapter has provided an overview of different aspects of the acute care system. A couple of bottlenecks can be found by looking at the patient flow model and the communication model:

### ***Possible bottlenecks from the patient flow model***

There are several points in this model (figure 2.1) that might be problematic in providing acute care of good quality. Below, they are listed:

- At the start, the patient needs to decide where to go: he does this on the basis of his knowledge of his complaint and of the acute care system. If he takes a 'wrong' decision this generally will not lead to lack of receiving treatment, but can cause a delay, which might cause or increase (permanent) health damage or even lead to death.
- In all following decision nodes (where multiple arrows leave a 'station'), a care provider needs to perform a triage procedure. This is a dynamic process that prioritises the needs of a patient based on the severity of their condition (Inspectie voor de Gezondheidszorg, 2004; Mish, 2007). Wrong decisions can lead to delay, which might cause or increase (permanent) health damage or even lead to death.

### ***Possible bottlenecks in the communication model***

There are several connections in this model depicted in figure 2.2 (missing) that might be problematic in providing acute care of good quality:

- General practitioners and hospitals sometimes have difficulties in reaching the central unit (Inspectie voor de Gezondheidszorg, 2004).
- Ambulances can only communicate directly with some hospitals. Other hospitals can only be contacted through the central unit.
- Hospitals cannot contact ambulance cars (only the other way around), while it can be valuable to be able to ask for information before the patient arrives (Inspectie voor de Gezondheidszorg, 2004).

### ***Other findings***

In section 2.5 the education of practitioners in the acute care field is explained. It is remarkable that both nurses and drivers already need to be employed by an ambulance service before they can start their education. This might be focused on learning-by-doing, but this should not be threatening the quality of care.

Section 2.6 and 2.7 have shown that there are many guidelines, protocols, norms, laws, and regulations that influence the acute care system. For all these documents it is important to look at:

- the exact influence they have on practice
- the way practitioners cope with all this information and knowledge

Currently, organisations in health care try to get an HKZ certificate to show that they are working actively on the quality of their care. When looking at the HKZ norms as described in section 2.6, it seems they are not that suitable for strict assessment.

The IGZ is the most important institution when it comes to measuring the quality of care in the Netherlands. Currently, their aim is to create quality or performance indicators for all fields of care, but as the RIVM concluded: in acute care, registration is not present or currently not suitable to measure the indicators they found. What should the IGZ do to be able to judge the quality of acute care in the future? This research does not look at the possibility of changing the indicators, or changing the registration systems, but takes a different route: is it possible to make the system improve itself on the basis of information on errors?

At the moment, the only detailed information published on errors is through disciplinary council verdicts. These reports can offer the opportunity to learn from mistakes. Important to note is that all focus in the verdict is on what the practitioner did or did not do: the disciplinary council does not look at the rest of the system. They do consider circumstances that influenced the knowledge or behaviour of the practitioner, but they do not check what should change about the system to improve it on a larger scale.



## 3 Theory and methodology

In this chapter, used theories and the methodology of research are described. The information sources used were already elucidated in section 1.4. The point of departure for this research is that there are multiple, mutually dependent, actors (“individuals or groups that play an important role within a problem case” (Bots, 2002)) in the complex system of acute care and that they have different, potentially conflicting, interests. The basic assumption taken in this research is that these different interests need to be taken into account in order to reach a successful solution. This view matches systems thinking theory. Both systems engineering and policy analysis, and the human factor approach that will be used in this research are part of systems thinking. All three theories will be described below in subsequent sections. In section 3.4, the whole approach is summarised.

All theories are described quite elaborate, because in health care, these theories and methods are rarely used. The readers of this report can possibly benefit from more knowledge of the way of thinking that lead to the research outcomes.

### 3.1 Systems thinking

Systems thinking is an approach to solving problems, by looking at the whole system surrounding the problem. It is about understanding the behaviour of the whole of acute care. The acute care system, with many actors, multiple organisational structures, laws, regulations, and technologies, can also be analysed in this way.

Systems thinking offers the opportunity to look at the whole of acute care in the Netherlands on a high, very aggregated level. This means that, rather than focusing on a very specific part of acute care (e.g. a law, protocol, or a communication technology), the goal of this research lies in understanding the overall functioning of the system and the relations and tensions within it. Chapter 2 has shown that the acute care system comprises a lot of different, complex aspects: systems thinking might help in structuring this, and might help in using all this knowledge to come up with a suitable solution.

This methodology also aims to take into account different aspects of the acute care system, unlike for example optimisation techniques. Since the goals of the system itself are not in one dimension (for example the financial dimension), it is not useful to use optimisation: it would require describing health outcome in terms of costs. Doing that will inevitably lead to more discussion, because: what is the value of a human life? Another example: a purely medical approach will not show organisational aspects that are causing problems. This shows that multiple dimensions of the system need to be taken into account when analysing the acute care system.

The main characteristics of systems thinking will be highlighted below:

#### ***Scientific holism versus reductionism***

For centuries, the sciences have mostly followed a reductionist approach, but the claim is made that not all problems can be solved this way.

Descartes (1637) was the first to describe the reductionist approach. He explains the scientific method in four steps: 1. Remove all information that is uncertain, 2. Divide everything in as small parts as possible, 3. Solve all small problems, starting with the simplest, and 4. Combine all solutions in lists to create an overview (Descartes, 1637). The reductionist claim is that, by understanding all parts, the problem in the system can be grasped.

The principle of the holistic view is that “the whole is more than the sum of its parts” (Aristotle, ± 330 B.C.E.). This contradicts the way of solving a problem the reductionist way. From the 1920s onwards, this principle has been used and elaborated in several scientific fields, such as biology, sociology, and systems theory. Systems theory dictates that the parts of a system can best be studied as part of the system, looking at the relations between these parts.

### **Characteristics of a complex system**

In systems theory, a system consists of elements and relations. The more elements or relations (or both), the more complex a system becomes. Complexity reduction will almost always occur when trying to make a model of a system, since the relations not always seem obvious. The danger of complexity reduction is that the model of the system becomes 'too simple': it may lead to a false understanding of the problem. On the other hand, taking into account too many aspects can 'clutter' the model, making it impossible to work with. The key is to choose such a level of complexity, that the model will reflect real behaviour and is workable. The following sections describe the strategy for this research.

### **Systems thinking and the acute care system**

The complexity of the acute care system, with many actors, organisations, laws, regulations, and technologies, and with aspects that cannot be 'translated' into one dimension, make it suitable for systems thinking. Systems thinking can provide a holistic way of analysing many aspects of the system at once, and with that, provide new insights into the functioning of the acute care system.

## **3.2 Systems engineering and policy analysis**

The purpose of systems engineering and policy analysis is to understand and clarify problems, and to assist (public) policy making. This theory is useful for studying the problems in the acute care system, because the system is complex: there are many actors within the system, they all have to work within a high-tech environment, with unpredictable and uncertain events (for example, an unknown number of patients entering the system at unknown times, with unknown health problems). This complexity makes it difficult to understand the behaviour of the system and to (re-)design the system or processes within it. Systems engineering and policy analysis can help in analysing the system and finding the 'areas of tension' within it (see below) (de Haan, Willemse, de Heer, Vos, & Bots, 2009).

The methodology behind systems engineering and policy analysis works well for a specific kind of problems. These are the main features of such problems (Bots, 2002):

- **Policy:** this is the decision that "directs future actions" (Bots, 2002). It is based on trade-offs within the system.
- **Organisation:** the way the system is organised. This comprises the practical layout, design, and implementation of the policies.
- **Process:** the "course of decision making" in which the actors have to negotiate about their different interests.
- **Technology:** this can be the solution to, or cause of, a problem. Examples of technology (in the broad sense) are: the acute care infrastructure, the C2000 communication system, but also the education of nurses can be seen as technology.
- **Administration:** there is always a political context, consisting of (political) actors and rules and regulations that are part of the system and influence the problem.
- **Network of actors:** many actors are involved in the system. Actors have a different perception of the problem, have their own interests, and usually are mutually dependent, which creates a network of actors.
- **Long-term orientation:** problems need solutions that will last: they should not create another problem in the future. This is sometimes referred to as the search for 'sustainable solutions'.
- **Complexity:** the problems and systems are complex. More factors, actors, and relations lead to more complexity. Walker (2000) gives the following explanation of complex systems: "the system being studied contains so many variables, feedback loops and interactions that it is difficult to project the consequences of a policy change. Also, the alternatives are often numerous, involving mixtures of different technologies and management policies and producing multiple consequences that are difficult to anticipate, let alone predict." (Walker, 2000) Time is also important, since organisations and decision making processes are not static over time. The dynamic complexity leads to uncertainty: this "emphasises that the choices must be made on the basis of incomplete knowledge about alternatives that do not yet physically exist, for a future world that is unknown and largely unknowable." (Walker, 2000)

Bots (2002) argues that, because of the characteristics described above, a multi-disciplinary approach is important. These problems cannot be solved mono-disciplinary: using only one discipline would reduce complexity too much, because the main assumptions and 'lenses' of that discipline influence the way one views the system, the problem, and the causes of that problem.

### ***Why is quality of the acute care system a 'systems engineering and policy analysis'-problem?***

Quality of the acute care system is a problem that can be analysed using the systems engineering and policy analysis methodology, because it has all the characteristics mentioned above: policy, organisation, and process play an important role in solving (and sustaining?) the problem. Technology and administration aspects are both present and need to be geared to one another. There is a large network of actors that are mutually dependent, and have to work in a high-tech environment. There is – or should be – a long-term orientation when searching for solutions. Finally, as shown in chapter 2, the acute care system is complex.

Two aspects of the methodology, areas of tension and the use of criteria, will be explained below.

#### ***Areas of tension***

Areas of tension are a dilemma: they are conflicting behaviour of the system, forces in opposite directions. An example could be the goal of quality improvement, without harming or losing personnel. Currently, quality improvement is pursued by disciplinary rules and regulations that penalise errors, while – as will be further elaborated in section 5.2 – penalising errors will not help in learning how to improve the system itself. The disciplinary rules and regulations will lead to punishment of personnel, while it is questionable whether these people are really 'bad apples' and whether removing them from the system will truly lead to improvement of the acute care system. Besides that, the presence of disciplinary rules and regulations keeps people from admitting errors: this prevents learning from mistakes and as such is another barrier for quality improvement. Punishing motivated people for error seems contradictory. This area of tension will be discussed in chapter 5.

Another area of tension was already highlighted in section 2.5: in rural areas, one wants ambulance personnel to 'stay in shape' – they need to experience enough emergencies to keep the quality high. This leads to a large coverage area, because that is the only way there will be enough emergencies. On the other hand, it is important that coverage areas are not too large: if travelling times increase, the quality of care goes down. The tension is thus between experience and travelling time: how can the number of emergencies per ambulance worker be high, without the travelling times exceeding the arrival time norms?

Areas of tension can be found by finding two things: a goal (or wish) – there must be a 'gap' between that goal and the current situation (or the situation that will emerge in the future when nothing is being done), and something that keeps you from reaching that goal. Together they form the dilemma.

#### ***Objectives and criteria***

Systems engineering and policy analysis use objectives: these are the goals that need to be reached within the system. The objective can be described as a desired change in a factor (Bots, 2002). A factor can be any characteristic of the system, but the factors that are directly linked to objectives are called criteria. For example, an objective in acute care may be "a 50% reduction in the number of fatalities due to heart failure by 2025": the criterion is 'the number of fatalities due to heart failure'.

When you want to reach that objective, you need to change other factors, since you cannot actively change the number of fatalities. Factors that you can influence that have an (indirect) effect on the number of fatalities could be 'the average A1 ambulance travel time', 'the number of AED machines' (Automated External Defibrillator: a machine that gives electric shocks to a patient, and instructs and guides the care provider through the process of giving heart massage and mouth-to-mouth respiration aid), or 'the number of lay people with a first aid training'. Note that increasing the number of AED machines will not directly influence the criterion: people also need to know how to use the machines (and dare to use them). These relationships can be depicted in a causal relation diagram, see figure 3.1:

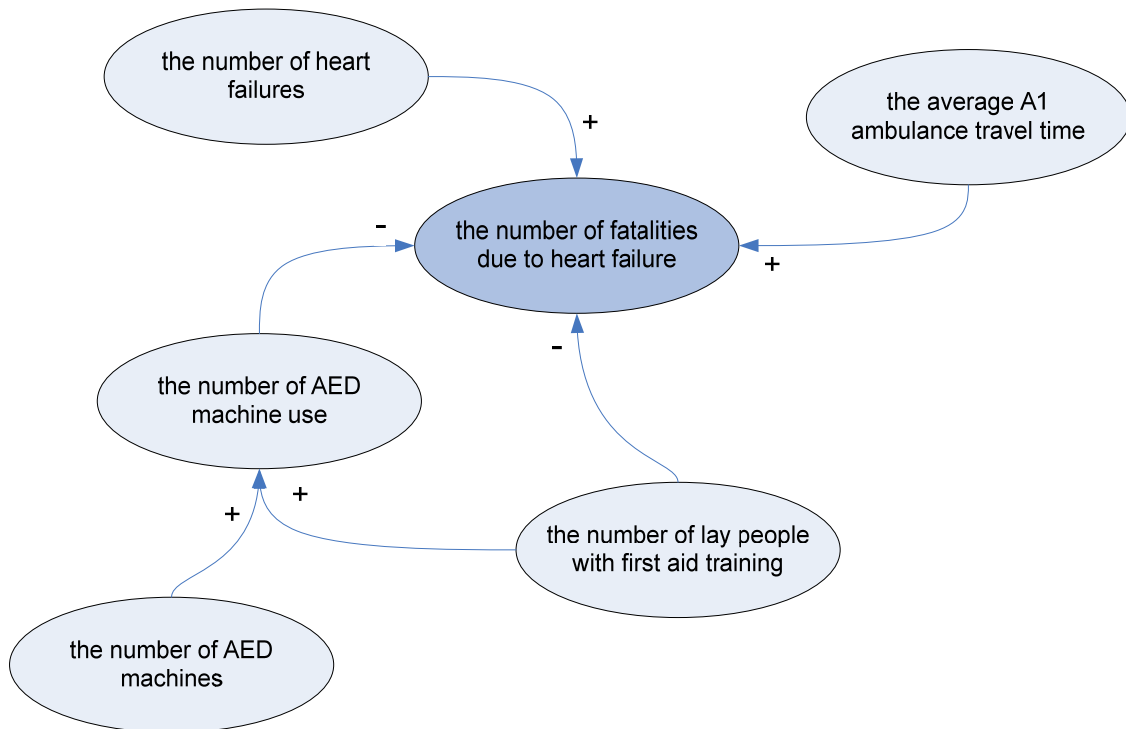


Figure 3.1: A causal relation diagram, depicting causal relations between several factors that can improve or worsen the criterion 'the number of fatalities due to heart failure'.

A relationship (arrow) can either be enforcing: positive (+), or the opposite: negative (-). The number of heart failures has a causal positive effect on the number of fatalities: this means, when more people suffer from heart failure, more will die from it. The other factors try to balance this, or even try to reduce the number of fatalities. The number of people with first aid training have two effects: they influence the number of fatalities directly, because they can provide heart massage, for example. The second effect is through the use of an AED machine. Both the number of AED machines and the number of people with first aid training contribute positively to the number of AED machine use, which in turn leads to a lower number of fatalities due to heart failure.

This causal relation diagram is far from complete (for example, we could add financial incentives to reduce ambulance travel time, or to take a first aid training, and so on), but it gets more complex once we add factors with more uncertainty. In figure 3.2, the same causal relation diagram is expanded with two extra factors: 'the number of people daring to take first aid training' and 'the number of times an AED machine does not work'.

The first factor is a factor that introduces uncertainty caused by human nature. The second factor introduces uncertainty about the (mal-)functioning of the high-tech AED machines that are used. The number of people that dare to take a course on first aid will not directly influence the number of fatalities due to heart failure, but it will positively influence the number of people with first aid training.

When using high-tech machines, it is always possible that the machine does not function, or malfunctions. The AED machines probably are no exception. Given that there must be a probability of failure, a fixed (unknown) chance of the machine malfunctioning, an increase in the use of the machine will lead to an increase in the number of malfunctions. This also makes the relation to the number of fatalities more complex. The number of times the machine is being used now has both a negative, direct (less fatalities) and a positive, indirect effect (more fatalities). Of course, the latter effect can never overcome the first effect: the probability of a machine malfunctioning cannot be greater than one. The malfunctioning of the AED machines can have other effects, though. What would you do if you heard that, when someone was trying to save a life, the equipment failed and the person died at that spot? Would you dare to be such a hero, take first aid training, and possibly get in the very same situation? A lot of people probably would not. People want to be able to fully trust machines, and statistics will not help either. A probability of 1 in 1,000,000 means there is still a chance it will occur when they are using the machine.



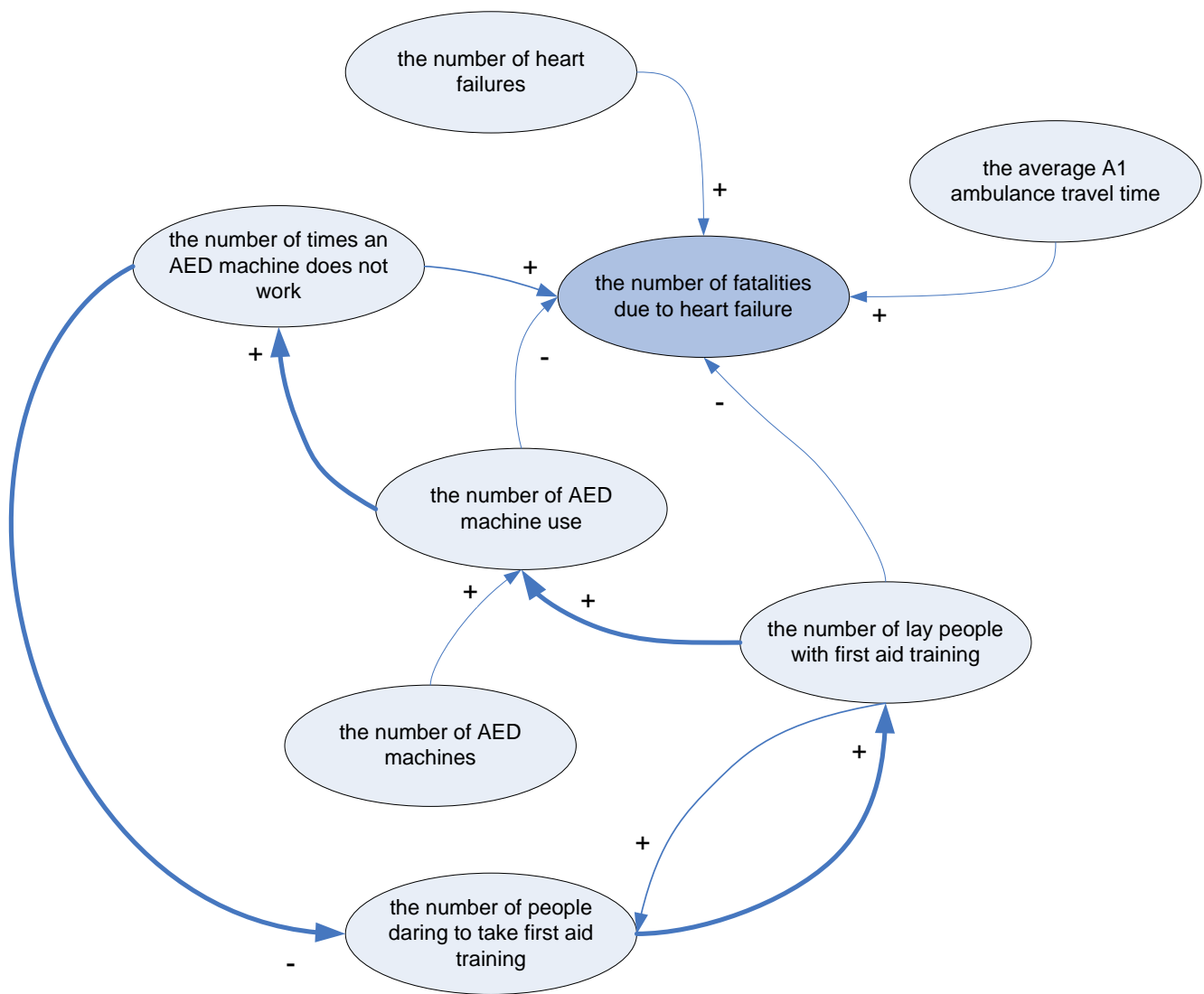


Figure 3.2: An extension of the causal relation diagram, depicting causal relations between several factors that can improve or worsen the criterion ‘the number of fatalities due to heart failure’.

With the influence of the malfunctioning AED machines on the fear of people, a so-called causal loop has been closed. When systems get more complex, there usually are many loops present. There is also a very small loop between the number of people with first aid training and the number of people that dare taking one. It is assumed that this will positively influence each other: when more people have had first aid training, their friends and family will be more interested, and less afraid of, taking first aid training themselves. The large loop, marked with the bold arrows, is more complex:

Starting at the number of people daring to take first aid training: **more** people daring will result in **more** people getting trained. This will result in **more** use of the machines. Unfortunately, this will also result in **more** malfunctions, which in turn will result in **less** people daring to take first aid training. When we continue going through the loop, we see that that will lead to **less** people with training, which will result in **less** use of the machines. That will lead to more fatalities due to heart failure. It will also lead to **less** malfunctions, but there is a lot of uncertainty as to how this again influences the amount of people that dare to take training. There is a chance that 1 malfunctioning incident can have just as much impact as 10 incidents, and that there should be an extra factor in the diagram, for example ‘the amount of news coverage on malfunctions of AED machines’.

Important about the factors introduced with figure 3.2, is that human behaviour often is very influential in systems like this. The news coverage would be another factor heavily influenced by human

behaviour and preferences (of sensationalist press, for example), and external to the acute care system: there is no way of keeping the reporters away from these incidents. The system has to deal with human nature, which can be very difficult.

This example shows that causal relation diagrams can be elaborated a lot, but choices need to be made about the detail and number of factors of the diagram. The goal is to show behaviour of the system in such a way that it can improve decision making on complex problems. When systems get very complex, it becomes hard to make clear and readable causal relation diagrams: in that case, often subsystems are made. The advantage of causal relation diagrams is that they provide insight into the behaviour of the system, and clearly show the criteria and the factors influencing them (de Haan, et al., 2009).

### 3.3 Human factor approach

Applying the human factor approach in this research adds a more specific point of view: it focuses on the complex interactions between the system and people (such as described in the example in the previous section), and the goal is to make a good fit. The approach has been chosen because of the many important human-machine and human-system interactions in the high-risk acute care environment. These interactions are central to the human factor approach. Some of those interactions have been described in chapter 2.

People are unpredictable, very complex in their behaviour, and thereby cause uncertainty. Those people are also part of the acute care system, which means that the system itself is also unpredictable, complex, and uncertain. A 'problem' with people is that they are very hard to change. The 'human factor trick' is to adapt all 'non-human' parts of the system in such a way that they fit human nature. This 'fitting' of the system should lead to improved performance of the people in the system, and because of that, of the system as a whole.

This approach has been applauded widely because it shows the need for systems that match human nature and provides a framework to see the parts that need 'matching' (Dekker, 2006; Leape, 1994; Rasmussen, 1997; Reason, 2000; Vicente, 2006; Woods & Cook, 1999).

Human factor engineering emerged in the first half of the twentieth century in North America, while at the same time, the field of ergonomics emerged in Europe. Essentially these fields are the same: they focus on expanding our knowledge of human capabilities and applying it to the design of technology (Human Factors and Ergonomics Society; International Ergonomics Association, 2000; Wikipedia, 2009). The goal is to optimise the fit between technology and people. 'Technology' should be interpreted in a broad sense: everything designed by people – tangible products, information structures, organisational structures, systems, policies and laws, etcetera – is technology (Vicente, 2006). In this research, the focus is on using the human factor approach to aid in systems design for the acute care system, given the characteristics of the people that have to work in, and are part of the system: it is about the fit between the human and technological parts of the system.

In this research, the term 'human factor' will be used in stead of ergonomics, mainly to prevent the idea that it is only about human-machine interaction (be it anthropometric, sensory, or cognitive): human factor is about human-technology interaction and thus also covers the interaction between people and policies, for example.

Vicente (2006) proposed a human-tech ladder, that contains five levels on which humans and technology must fit. Below, a model with these five levels is presented in figure 3.3.

Central to the human-tech ladder, and a driving factor is the human or societal need (X). To meet this need, everything must be geared towards reaching that goal, while all technology should be matched with the human factors on each level. The levels of the human factor are in the right column and the technologies are in the left column. It is called the 'human-tech ladder', because on each level, the technology and the human factor must match and together create a rung of the ladder. The only way of reaching the top goal – the human or societal need – is to make sure that all the rungs are intact.

For example, when the societal need is 'public health', the match between technology and the human factor should be present on all levels. Medical personnel play a frontline role in health care: they

should be able to do their work well, as part of the system, in order to meet the need for public health. This means that they have personal needs that should be met for them to be able to contribute to public health. This means that, for instance:

- on the physical level, they need to have tools that are easy to use,
- on the cognitive level, they need to have the right information before being able to treat a patient,
- on the team level, they need to know what their responsibilities are, and who is in charge,
- on the organisational level, they need to have staffing levels that are sufficient (to make sure that they do not have work shifts that are too long, which can lead to lower quality), and
- on the political level, they need the government to allocate enough budget to make sure they can do their job (and comply with the laws and regulations the government also imposed).

These are only a couple of examples, but it shows the basics of human factors: if, even on only one level, the human factor is not taken into account, the societal need will not be met, or only partly. More examples will be given in section 5.1.

It is not necessary to 'complete' all rungs of the ladder from bottom to top in one order. Sometimes this is even impossible, for it will threaten the success of the change. For example, when laws and regulations are not in place yet to encourage error reporting, it is no use to change this on the team or psychological levels: when those would be implemented before the political level, the whole thing would fail. For the change to be complete and to become successful, however, it is necessary that all levels have been taken into account.

The human factor approach requires to look at the system as a whole, to make sure that all parts are following the same goal. Looking at the different levels of the system at the same time is typical of systems thinking. The human factor approach is besides holistic (looking at the whole system), also very detailed (thinking about medical tools, for example): this is because that level of detail is necessary to assess the whole system. There needs to be synergy on all levels for the whole system to move towards public health, and the synergy cannot be judged when looking at it only superficially.

The examples described above also show the complexity of making a system that is completely attuned to the human factors it deals with. On the other hand, it is not more complex than when designing a system without the human factor approach, since the approach can serve as a guiding principle when going through all aspects of the system. The human factor approach gives the opportunity of designing a system that fits, which will be more successful, and thus needs less adjustments later on.

In this research, the human factor approach will be used as a way of focusing on the acute care system. The research specifically focuses on the way technology is designed in relation to the human factor on a high level.

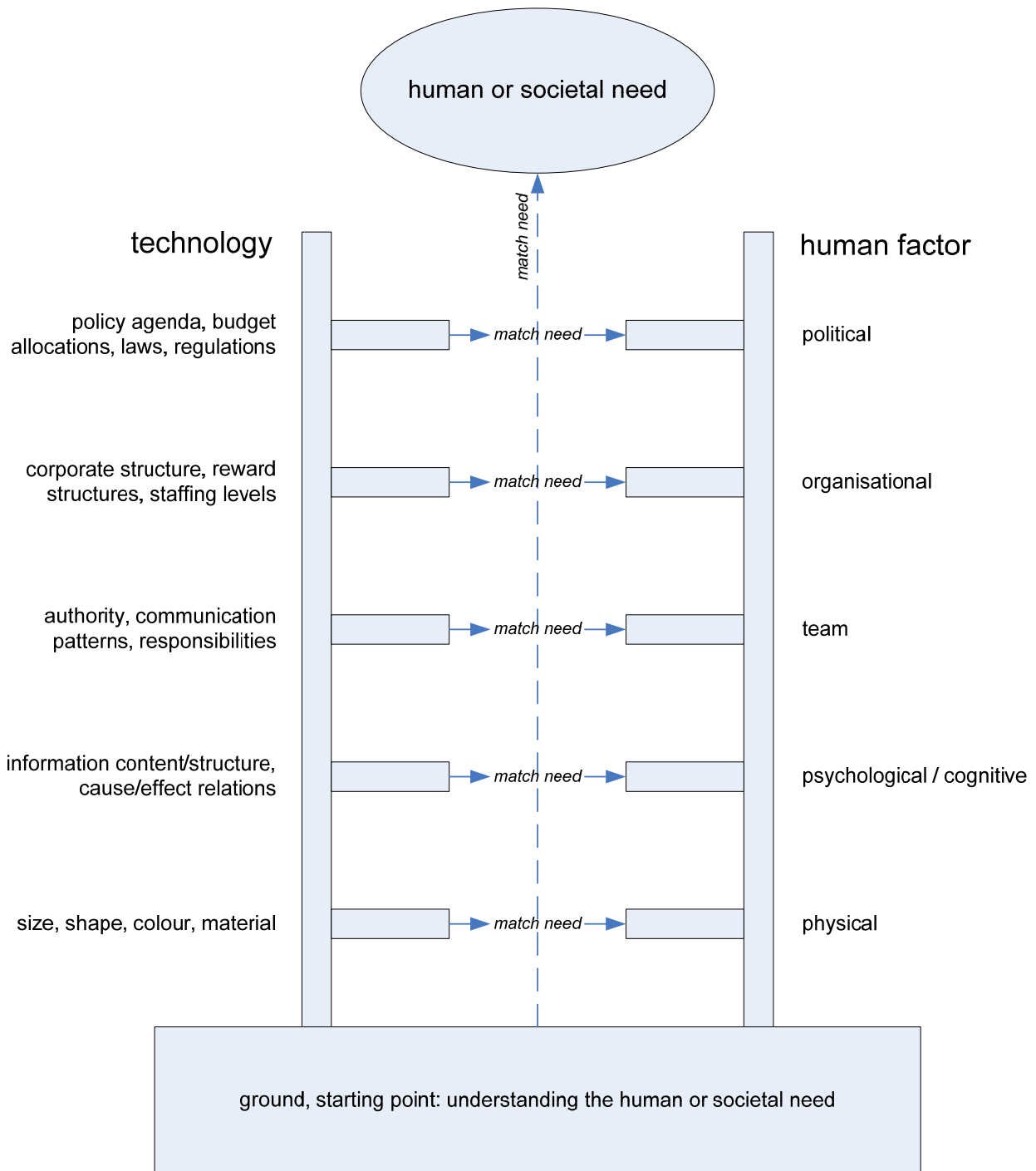


Figure 3.3: Human-tech ladder, based on Vicente (2006), with examples of technologies on each level

### 3.4 Conclusion

The methodology used can be summarised as follows:

- Systems thinking: the acute care system is not being 'cut into pieces', but viewed as a whole to include the complexity of the system.
- Systems engineering and policy analysis: this method is a practical way of using systems thinking. The goal is to make the system explicit, including its areas of tension.
- Human factor approach: this approach forms a demarcation of the systems engineering and policy analysis method. It is used to focus on one aspect (human factors), rather than on

another or on a number of aspects (for example finance or cost-benefit, or a medical approach). The human factor approach will also lead to solution alternatives within this field.

Since this method is about looking and, in the end, changing the system on different levels, the ministry of Health is a suitable problem owner to actually address all levels (with other actors in the field).

Below, figure 3.4 shows the construct of this research. It shows the theories that together form the method, and it shows the specific knowledge used as input for this research.

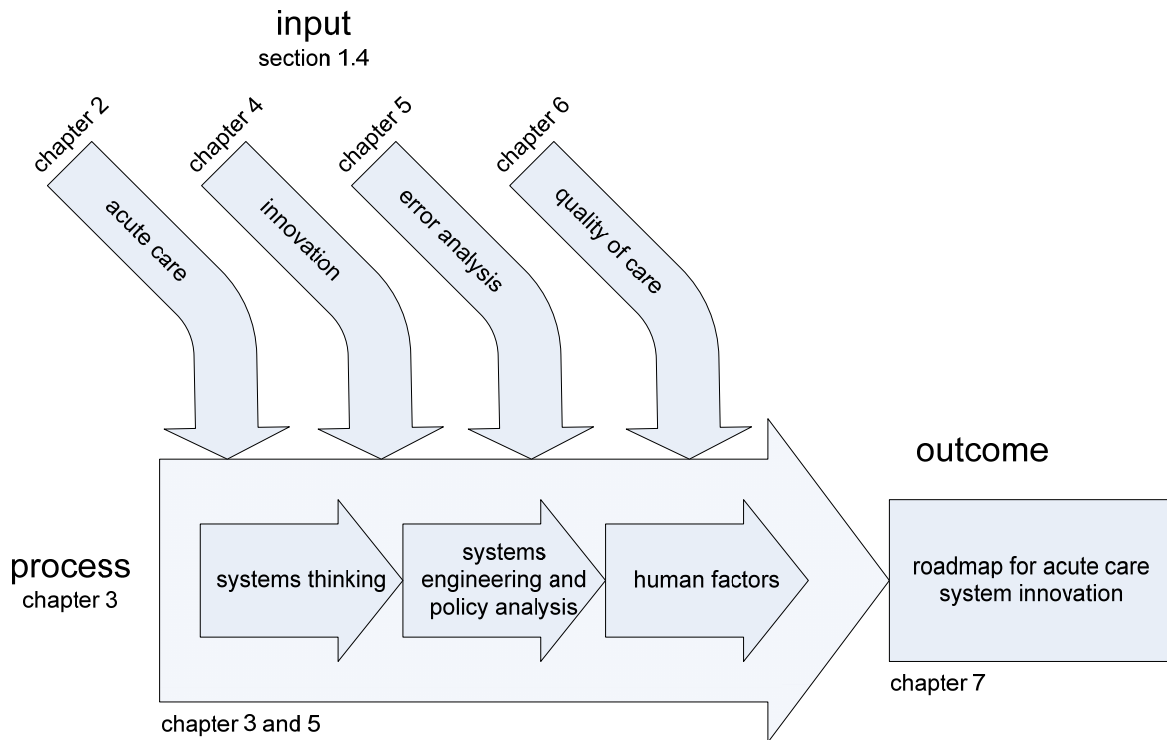


Figure 3.4: The process, input and output of this research

The methods used in this research are enriched with other knowledge from the fields of acute care, innovation, error analysis, and quality of care: the methods described in this chapter will act as a 'seed-bed' for other theories in this research – together they answer the questions posed in this research.



## 4 Innovation of acute care: what, why and how?

The premise of this research is that the quality of the acute care system is lower than we like, and that we need changes in the acute care system to increase that quality. This chapter discusses those changes, called innovations (the matter of quality will be treated in chapter 6). First, in section 4.1, innovation is defined, a variety of goals of public sector innovation are presented, and different types of innovation are discussed. This section is quite abstract, since that is necessary to see what innovation is about on a system level, but examples will be presented. Section 4.2 describes the innovation process. In section 4.3 and 4.4, the focus is on obstacles for innovation, but enablers are also discussed. Finally, section 4.5 summarises the findings of this chapter.

### 4.1 What is innovation and do we need it?

Innovation is the process of improving by introducing new (ways of doing) things (Bray, Konsynski, & Streater, 2007; Mish, 2007). Innovation is “more a verb than a noun” in the sense that it refers to an ongoing process with a drive towards improvement (Bray, et al., 2007). To elaborate on the definition: “Successful innovation is the creation and implementation of new processes, products, services and methods of delivery which result in significant improvements in outcomes efficiency, effectiveness or quality.” (Mulgan & Albury, 2003) This sounds straight forward, but it is not: innovation is complex and there is “no simple formula [...] to ensure successful innovation” (Improvement and Development Agency, 2005).

Innovation in the acute care system can be almost anything: from improving an AED machine, to changing the working schedules of ambulance personnel, so they are working less hours in one shift, for example. A very important characteristic of the acute care system is that it is mainly a public sector system. This has consequences for the types of innovation, the goals and the processes of developing innovations, as will be described below.

#### ***‘Classic’ private sector innovation versus public sector innovation***

Classic innovation science literature focuses on the private sector, and uses competition as a main driving force for innovation: there, effective innovation means survival and growth of the organisation (Improvement and Development Agency, 2005). In the public sector, competition is usually not present – although in the semi-public health care sector, reforms are aiming for more competition in some fields. As explained in section 2.7, from 2011 onwards, there will be more competition in acute care as well, although it is not clear yet what the consequences will be (at the moment, the tendering procedure for a license for ambulance care in one region is proposed to take place only once (a permanent appointment of the license), which means that once all ambulance care licenses are assigned, there is no competition anymore). Public sector organisations have different pressures and goals, which in the past have led to a lack of interest in, and priority of, innovation by the public sector (Bhatta, 2003). According to Mulgan and Albury (2003), innovation in the public sector is often seen as “an optional luxury or an added burden.”

#### ***Why do we need innovation in the public sector?***

There are multiple reasons why innovation in the public sector is useful (Donahue, 2005; Improvement and Development Agency, 2005; Mulgan & Albury, 2003):

- to keep up with (altered) public needs
- to match services better with local or individual needs
- innovations enable new needs to be met and old needs to be met more effectively
- innovation can be used to contain costs and to improve efficiency, especially in view of (tightening) budgetary constraints (see below)

These reasons more or less apply to acute care as well: the demand for acute care may increase, which means that acute care services need to adjust to that. Another example: cost containment is an issue in the current financial climate, so it might be wise to stay ahead of cost cutting by innovating: the services must be delivered.

Public organisations have a large impact on many people: they have socially important tasks (Donahue, 2005). This makes innovation important. It also shows that public sector innovation has the

potential to create more value than private sector innovations (Donahue, 2005; Improvement and Development Agency, 2005). The risks are bigger as well: when innovations fail, the public has to pay.

As Mulgan and Albury (2003) explain about rising costs in the public sector: “Without innovation public services costs tend to rise faster than the rest of the economy. Without innovation the inevitable pressures to contain costs can only be met by forcing already stretched staff to work even harder.” As a reason for the faster rise of costs of public services, they present “the lack of competition in the public sector and ‘Baumol’s disease’, where gains in labour efficiency tend to lag behind gains in capital efficiency (the public sector is disproportionately subject to this due to the nature of its service provision).” (Mulgan & Albury, 2003)

For acute care, the specific goals for innovation are:

- improving health outcome for patients (increase effectiveness)
- reducing costs of maintaining the system (efficiency and innovation: reaching and raising the optimal production curve)

To explain the latter goal: at this moment, the system has an optimal ‘production’ curve: this means that with the current characteristics of the system, it should be possible to get the maximum output for any given input. When the system is not efficient in using its resources, it performs below this optimal curve, see figure 4.1. Efficiency improvement can result in the optimal production curve being reached. Innovation can raise the optimal production curve.

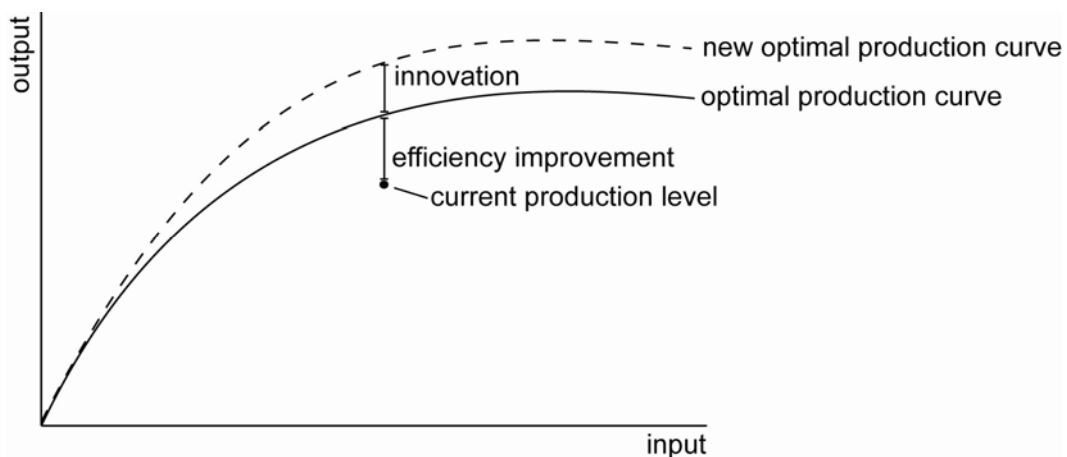


Figure 4.1: The difference between increasing efficiency and innovation.

The difficulty with the acute care system is that it is hard to say what the optimal production curve is, and whether this currently is being reached. It is even hard to say what the current production level is. For what is production? Saying that production is the number of patients being treated in the system is not adequate, since the number of patients is leading: the system cannot decide on the number of patients (apart from selection of acute versus non-acute patients) – patients just show up and the system has to deal with them. This is also the difficulty in cost containment: if more patients show up, the system will need more money.

More insight into the functioning of the system is needed. In any case, it is safe to say that the acute care system needs to handle its resources as optimal as possible, especially in the light of the drastic cutbacks the minister of health has proposed for the coming years (Ministerie van Financiën, 2009).

### **Degrees of impact**

A way of characterizing innovations is by their impact on the system. The most accepted categorisation is: incremental, radical, and systemic (or transformative) innovation (Improvement and Development Agency, 2005; Mulgan & Albury, 2003):

- **incremental innovation:** these are minor changes, but these small continuous changes are important to keep up with changing needs of patients.
- **radical innovation:** these are less frequent, but larger changes, such as the development of new products or services, or of “fundamentally new ways of doing things in terms of organisational processes or service delivery” (Improvement and Development Agency, 2005).
- **systemic innovation:** these innovations are very rare. They transform the whole system, by for example the creation of new structures, or new organisations. A systemic innovation can



be seen as a number of radical innovations being implemented at once. These innovations can take decades to complete.

In figure 4.2 below, the difference between incremental and radical innovations is shown more clearly. While both are useful for improving the acute care system, incremental innovations stay within the same developmental or optimisation path, and radical innovations create a new path with a new 'ceiling' (de Haan, 2007). Hopefully, a new innovation is starting to develop before or when the ceiling is reached, but it can occur that there is no new innovation to 'heighten the ceiling'. Examples within acute care are improvement of training of ambulance personnel: this is incremental optimisation. A radical innovation could be a completely new treatment protocol that improves survival chances a lot for people with a certain illness: then the new protocol is the radical leap, while optimising the protocol, and ensuring that all ambulance personnel execute it in the right way, form the period of incremental optimisation.

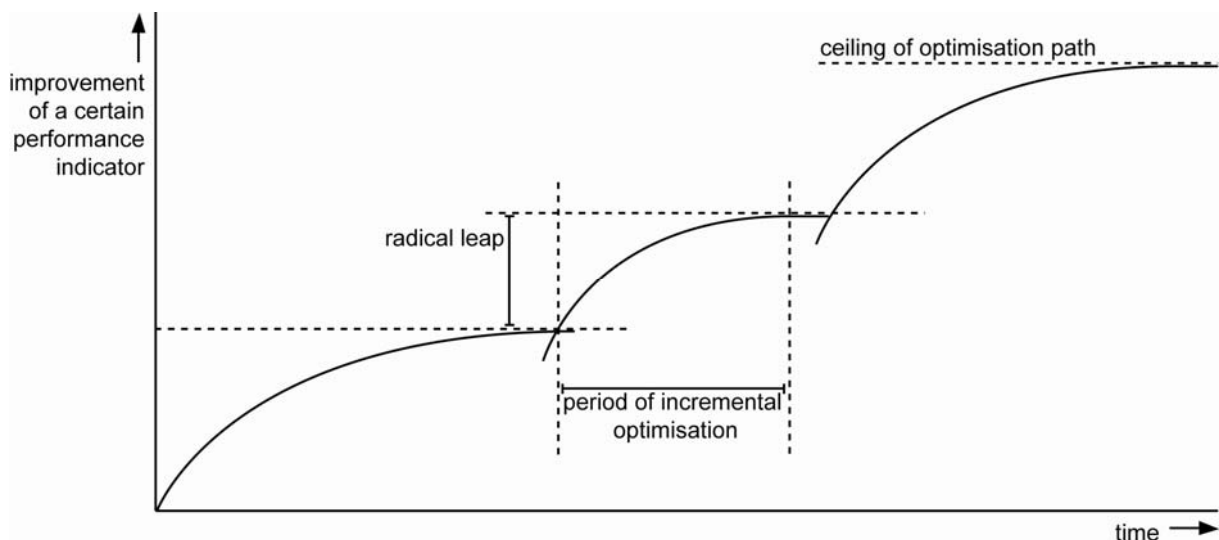


Figure 4.2: Innovation of a certain performance indicator, showing the period of incremental optimisation, until the ceiling of that optimisation path has been reached. The increase in the height of the ceiling is a radical innovation leap (based on de Haan (2007)).

### Types of innovation

In classic innovation literature, different typologies of innovation have been put forward: among others, the Schumpeterian distinction between product and process innovations, and the extension of that typology with service innovation (Bray, et al., 2007; Van der Klauw, 2009). The Improvement and Development Agency (2005) propose a typology that is applicable to both the private and public sector. They distinguish five types of innovation (Improvement and Development Agency, 2005):

- **strategy / policy innovation:** for example new objectives
- **service / product innovation:** for example changes in the design of the service or product
- **delivery innovation:** for example new ways of interacting with patients or new ways of delivering the service
- **process innovation:** for example new procedures or a new organisational form
- **system interaction innovation:** for example new (or improved) ways of interacting with other actors within the system

These types can be seen as a way of characterizing innovations, but also can be seen as a roadmap, quite similar to the human-tech ladder as presented in chapter 3: in what ways and on what levels can you introduce innovations? Below, the human factor levels of the human-tech ladder and the five types of innovation are combined in table 4.1:

Table 4.1: The human factor combined with different types of innovation

Human factor	Types of innovation
Political	strategy / policy innovation
Organisational	process innovation system interaction innovation
Team	process innovation
Psychological / cognitive	service / product innovation delivery innovation
Physical	service / product innovation delivery innovation

In table 4.1, it is shown that the different types of innovations all operate on different levels of the human factor. Strategy or policy innovations occur on the political level, process innovations occur on the organisational and team levels, and system interaction innovation occurs on the organisational level. Service, product and delivery innovation occur on both the psychological and the physical level, since they can interact with both facets of human nature.

The risk of the typology of innovations is that it is possible to think that innovations only influence a certain level of the system, while – in line with systems thinking and the human factors approach – actually the different levels also influence each other. Innovations thus can have an emphasis (for example, being a policy innovation), but they will interact with other levels of the system. For incremental innovations, the interactions with other levels will be limited, but for radical innovations, there is a tendency to have influence on other levels. When implementing a radical innovation, it is very likely that other levels are important to involve and adapt to, to increase the chances of success for the innovation. In figure 4.3, the differences between types of innovations are shown in the human-tech ladder, using examples of innovations:

The examples mentioned in figure 4.3 will be explained here:

- **new regulation on error reporting:** for this innovation, almost all levels need to be taken into account, because the regulation will influence organisations (that will have to adapt their own procedures and have to inform their staff), teams (that will have to create a new team culture that fits with the new error reporting regulation), and individuals on the psychological level (they will have to internalise the essence of the regulation and a culture of error acknowledgement and reporting).
- **new criteria for counting ‘natural deaths’:** if a hospital for instance decides to change the way they decide whether a patient has died a natural death, this influences other levels. First of all, it should be checked whether this is allowed by law on the political level. It will further impact the political level since a new way of counting natural deaths will also result in other ‘scores’ on the quality indicators the IGZ uses: it is the question whether that is correct. It influences the team level, because the change might mean that communication patterns change, and finally, it influences individuals both psychologically, cognitively and physically: the new criteria need to be understood, and they need to be used in practice, which means that they physically (technically) need to be able to test a deceased patient for those criteria.
- **new responsibilities for team members:** this innovation has an odd T-shape, since it also contains an extra section. New responsibilities of course influence the team members on the psychological level: it can create tensions, for example. Besides that, the new responsibilities can also interact with the political level: for instance, it is not allowed by law to give a nurse the responsibility for administering medications.
- **new automatic dispensers of disinfectant:** introducing new dispensers for disinfectant that work automatically can improve hygiene and reduce the number of infections. Even this simple innovation interacts with another level, the psychological / cognitive level, for the people using the new machines need to understand how it works, and perhaps they need to be persuaded to use them.

As can be seen on the basis of these examples, innovations do not ‘stay on their own level’. Mostly, they impact a number of other levels, which means that the innovation should be adapted to the needs of all levels of the system to be able to be successful.

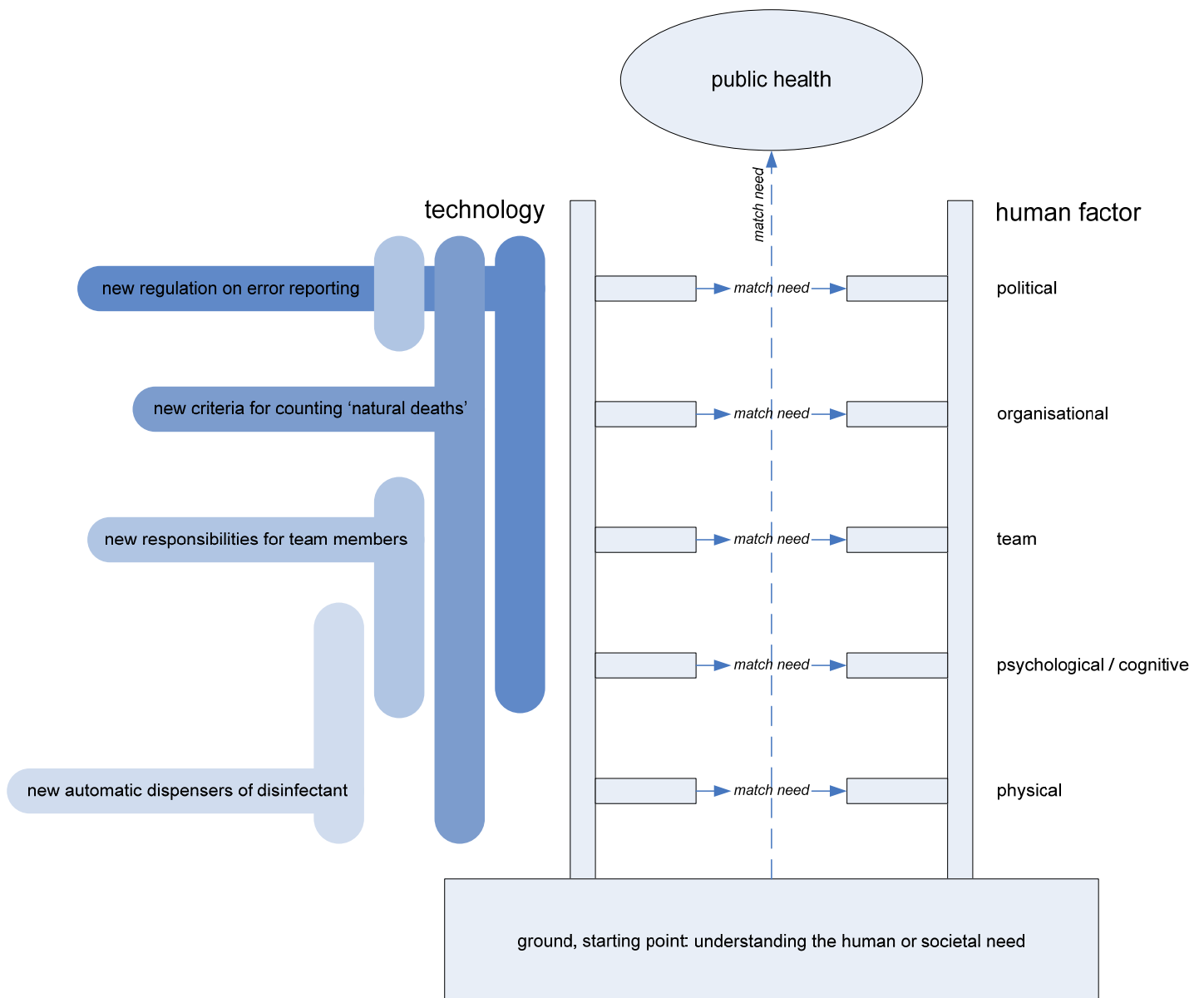


Figure 4.3: The human-tech ladder with examples of innovations with a 'central level', that also influence other levels, creating a T-shaped influence.

### Top-down or bottom-up

A last distinction between different innovations is the way the innovation is implemented. This can be either top-down, which makes use of "prescription, regulation, and support" (Mulgan & Albury, 2003), or bottom-up, which originates within the system, and is enabled and facilitated by the top levels.

## 4.2 The innovation process

The innovation process has a couple of phases that are quite similar to those in the design process or in the policy analysis process. The following steps can be distinguished (based on (Borins, 2006; de Haan, et al., 2009; Donahue, 2005; Improvement and Development Agency, 2005; Mulgan & Albury, 2003)):

1. **analysis:** what is the problem?
2. **design:** what should be done about the problem, creating alternatives / options
3. **testing / prototyping:** testing the design on a small scale
4. **decision:** choice of alternative, will a new design be implemented?
5. **implementation:** getting the new design in place, persuading people and organisations, changing the system to accommodate for the new design
6. **evaluation:** is the innovation successful?

In some cases, the testing phase is too difficult to execute fully, for example when it concerns a systemic innovation. Below, scientific findings on characteristics of successful innovation design are presented.

### 4.3 Steering innovation: obstacles to, and enablers of innovation

In this section, obstacles that hamper innovation are described. Besides that, also enablers of innovation are elucidated.

#### **Obstacles to innovation**

Different researchers defined several barriers that can obstruct innovation. Here is an overview (Borins, 2006; Improvement and Development Agency, 2005; Mulgan & Albury, 2003):

- culture of risk aversion
- poor incentives to innovate
- inadequate resources
- reluctance to stop failing programmes
- poor skills in change and/or risk management
- short-term budgets and planning horizons
- delivery pressures and administrative / bureaucratic burdens
- lack of alignment of technological, cultural, and organisational aspects
- legislative or regulatory constraints
- coordination difficulties

Borins (2006) found that the obstacles can be divided into three main classes:

- obstacles within the organisation / bureaucracy
- obstacles in the political environment
- obstacles in the external environment (for example the general public, or those affected by the innovation in the private sector)

Interestingly, Borins found that in the 300 cases he analysed, the largest number of obstacles was within the organisational and bureaucratic context.

To identify obstacles when working on the implementation of an innovation, Borins (2006) made a 'check list' with questions that can indicate the presence of an obstacle. This list of questions is cited in appendix D.

#### **Enablers of innovation**

Luckily, Borins (2006) also found a number of enablers of innovation: these circumstances can be seen as being, not prerequisite, but very stimulating for innovation within a system:

- **innovative culture** must be **supported from the top**
- **reward innovative people** or teams in the system (not per definition financial, also recognizing and valuing their efforts helps)
- **resources for innovation**: inadequate resources are the biggest obstacle for innovation
- **diversity** of staff background: people with different backgrounds have different perceptions and ideas, which will help in creating innovative ideas
- **look outside** the system: learning from other organisations and systems
- **innovation is everyone's responsibility**: information and ideas from all levels of the system are important
- **experiments are essential** for innovation (Borins (2006) also mentions that this could be encouraged by reducing the costs of failure for the innovator)
- **evaluation is essential** for innovation

These enablers can be implemented or pursued (a culture, for instance, cannot be implemented), and hopefully they together create breeding ground for innovation.

### 4.4 Acute care system obstacles hampering innovation

Of the obstacles to innovation described in the previous section, the following probably occur in the acute care system:

- **Inadequate resources**: organisations in the acute care system deal with three types of inadequate resources: first of all, the development of innovations costs money. Since health

care often has funding problems, it is likely that there is no money left for the development of innovations (especially since there is no guarantee that the return on investment will be high). Second, people in acute care are essentially a kind of 'fire fighters': when there is an emergency, all other things have to wait, resulting in no time to think about innovation. Finally, there is a lack of people that are trained to design innovations: these people need to have the skills to look at all levels of the system.

- **Short-term budgets and planning horizons:** the short-term way of working has been explained above: people in the acute care system are like fire fighters.

Besides that, also other obstacles mentioned in section 4.3 might be present. It is important to be attentive to these obstacles, since they can hamper innovation and might have large consequences.

#### **4.5 Conclusion: what are requirements for an innovation-supporting system?**

"Successful innovation is the creation and implementation of new processes, products, services and methods of delivery which result in significant improvements in outcomes efficiency, effectiveness or quality." (Mulgan & Albury, 2003)

For acute care, the specific goals for innovation are improving health outcome for patients (increase effectiveness), and reducing costs of maintaining the system (efficiency and innovation: reaching and raising the optimal production curve). The difficulty with the latter goal is that it is hard to say what the optimal production curve is, and whether it currently is being reached. Cost containment is also difficult: if more patients show up, the system will need more money. More insight is needed, but in any case, the acute care system needs to handle its resources as optimal as possible.

An innovation typology of five types of innovation is proposed that are applicable to both the private and public sector. It is shown that the different types of innovation all operate on different levels of the human factor. The risk of the typology of innovations is that it is possible to think that innovations only influence a certain level of the system, while the different levels also influence each other. Innovations thus can have an emphasis, but they will interact with other levels of the system. As can be seen on the basis of the examples provided in section 4.1, innovations do not 'stay on their own level'. Mostly, they impact a number of other levels, which means that they should be adapted to the needs of all levels of the system to be able to be successful.

In section 4.2, the innovation process has been elucidated. Obstacles for innovation, as described in section 4.3 occur within three categories: the organisation / bureaucracy, the political environment, and the external environment. The internal one – obstacles within the organisation – occurs most often. The enablers of innovation that were mentioned in section 4.3 can help in creating an environment that supports and fosters innovation.

The most important requirement for an innovation-supporting system, is that it should accept and support the approach of innovation development that takes into account the different levels of the system. There are also other points that could help the system forward, such as removal of the obstacles to innovation, and introduction or enforcement of the enablers of innovation as described in section 4.3.

In acute care this means that the system should be changed in the following way: obstacles to innovation should be removed as much as possible; enablers of innovation should be implemented; the process of innovation should be started; and innovations should be T-shaped.

The approach of innovation development that takes into account different levels of the system, as is closely linked with the human factor approach, will be expanded in the next chapter. In the next chapter, the process of analysis of errors within the system will be discussed. The outcomes of the analysis can be used to come up with innovations.



## 5 The human factor and human error: matching systems and people

In this chapter, the human factor approach is used to create a way of looking at the performance of the acute care system. The human factor approach has already been highlighted in section 3.2.3. In section 5.1, the human factor approach will be applied to the acute care system. Since looking at errors can be a useful way of finding flaws in the system, section 5.2 focuses on what 'human error' is. How to analyse errors is elucidated in section 5.3. In section 5.4, several tensions within the acute care system that influence the possibilities of looking at and handling error are discussed. All findings of the first part of this chapter will be summarised in section 5.5. Section 5.6 outlines how to learn from errors, and concludes with successes from other fields: aviation and anaesthesiology. Finally, section 5.7 draws conclusions.

### 5.1 The human factor approach applied to the acute care system

In acute care, the human factor approach can be applied to various levels of the system. Vicente's model as discussed in chapter 3 is presented again below in figure 5.1, but this time it also contains examples from the acute care system. In this case, the societal need is public health: all designs should be made in such a way that they contribute to public health. At each rung, a few examples are given of technologies or problems revolving around technologies in acute care.

### 5.2 Using error analysis as a starting point for system innovation

Analysing the whole acute care system on the basis of the human factor approach is a lot of work. Looking at errors can be a useful way of decreasing the amount of work for analysis, by creating a limiting focus and will help finding flaws in the system. These flaws can then be judged and the system can be redesigned in such a way that errors of that type will not occur anymore (or at least less often). In this section, the definition and meaning of human error will be discussed.

#### ***When things go wrong: two types of human error***

When an error occurs, very often the person closest in time and space will be blamed for it (Dekker, 2006). This suggests that the complex system in which the error occurred is a safe and well-functioning system, apart from the person that made a mistake. This automatically results in solutions that point towards changing that person: apparently, s/he needs more education, or reprimanding to prevent new errors from occurring.

In this section, a different view on human error is explored. Rather than seeing human error as the cause of an accident, it is seen as a symptom of a problem deeper inside the system (Dekker, 2006; Reason, 2000; Woods & Cook, 1999). Seeing human error as a symptom of system failure provides an explanation based on human factor theory. As Dekker (2006) puts it – is it about “bad people in safe systems, or well-intentioned people in imperfect systems?” These well-intentioned people are compromised in their pursuit of success, because of limited resources, uncertainty, or other imperfect features of the system they have to work in (Dekker, 2006; Woods & Cook, 1999). Rather than concluding with blaming a person, one can learn from finding the system failure. Dealing with such a system failure is usually done through putting 'system defences' in place.

#### ***Health care sticks to the first approach, or will this change?***

In health care, the first approach (blaming the person) is dominant. According to Reason (2000), this is not very strange, since it has some advantages: blaming persons is “emotionally more satisfying than targeting institutions” (Reason, 2000), and for institutions it can be in their own interest to blame a person instead of their own system. This can be legally more convenient as well (Reason, 2000). The effects of blaming and shaming will be elucidated in section 5.3. Besides that, personnel in health care feel they cannot make mistakes. This will be discussed in section 5.4.

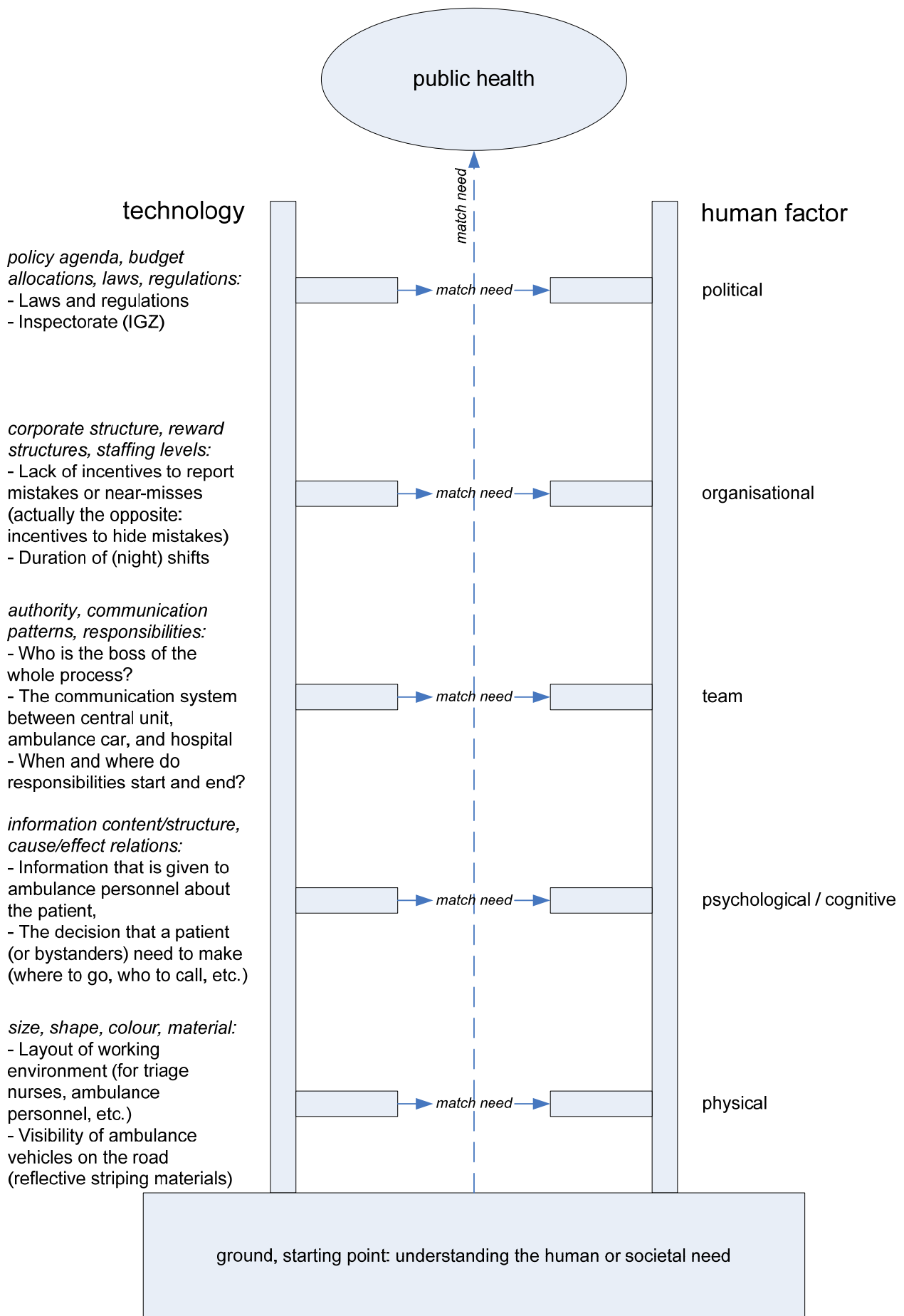


Figure 5.1: Human-tech ladder with examples from the acute care system, based on Vicente (2006)



Sticking to the first approach can be dangerous, because of two characteristics of error:

- Errors are made by everyone, not only by 'bad apples'
- Errors tend to recur: patterns can be found when looking at errors

This means applying a system approach to acute care could prevent errors in the future; "Without a detailed analysis of mishaps, incidents, near misses, and 'free lessons,' we have no way of uncovering recurrent error traps or of knowing where the 'edge' is until we fall over it." (Reason, 2000) This 'edge' will be discussed in the next section.

### **5.3 Error analysis: looking at error while you were not there**

In section 5.2 the statement was made that we can learn from errors and with those lessons, improve the acute care system. The main question that will be treated in this section is: how to do it? How to analyse error? Unfortunately, this is not as easy as it might seem. First of all, the analyst researching the error will be bothered by his own psychological features without noticing. The most prominent effects that should be taken into account are described in section 5.3.1. Second of all, the person and organisation making the mistake, are also 'victims of human nature', in the sense that there are other psychological effects that cause and/or influence erratic behaviour. These will be elucidated in section 5.3.2. Finally, in section 5.3.3, the human-tech ladder will return, and all findings of section 5.3 will be linked to the different levels.

#### **5.3.1 Psychological features of the analyst looking at error**

In this section, two psychological effects will be described that influence the way the analyst works: biases, and local rationality. These effects are of importance to the way the analyst works.

##### **Biases**

When researching an accident after it happened, there are multiple factors influencing our 'reaction to failure' (Woods & Cook, 1999). One of the most important and influential is the hindsight bias (Dekker, 2006; Woods & Cook, 1999). When evaluating what happened, you work backwards, already knowing the outcome. It becomes easy to say: "How could they have missed that?" or "How could they not realise that a would lead to b?" There are a couple of psychological biases that 'bother' us when looking at an accident after it happened (Woods & Cook, 1999):

- People tend to judge the quality of the process by its outcome: a poor outcome must be caused by a poor process, and a good process must lead to a good outcome. This is called outcome bias.
- Once people know the outcome, they tend to find that outcome more probable than other possible outcomes. On top of that, people are unaware of this effect. Together, these are called hindsight bias. Sometimes, people even think that the outcome was inevitable, considering a series of events in the process: that is a simplification of history – it assumes a linear series of events and oversimplified causality (action a will always lead to event b) (Dekker, 2006).

The implications of these biases for analysis and judgement are large (Woods & Cook, 1999):

- "Decisions and actions having a negative outcome will be judged more harshly than if the same process had resulted in a neutral or positive outcome." (Woods & Cook, 1999) Woods and Cook (1999) say that this result can be expected even when people are warned about it.
- People analyzing and judging a case will tend to think that people involved knew more about the situation than they actually did, and that those people should have realised how their own actions would lead to the outcome. The people analysing the case have 'situation awareness': they know what happened. When the accident was happening, people did not have, or lost, situation awareness (Dekker, 2006).

When reconstructing the accident, the hindsight bias is usually present. It often happens that information that was not available during the accident, turned out to be critical. This information is then interwoven in the recount of the accident to show that "they should have seen it". Looking back at the case described in section 2.11: an ambulance nurse does not recognise – or at least does not act upon – the signs of a possible cerebral haemorrhage and therefore does not handle the patient in the way that would have been necessary (*Uitspraak in de zaak 06/255Vp*, 2007). In hindsight, this was critical information: the patient died as a result of SAH, massive cerebral haemorrhage. It is important

to take the hindsight bias into account: this was not the only error leading up to the death of the patient, there was no (complete or direct) one-on-one causal relation between the actions of the nurse and the death of the patient, and – very important – at that moment, the nurse did not know what was happening: he had a lack of situation awareness.

### ***Local rationality***

People in safety-critical systems constantly have to play different roles. Their basic tasks are to pursue the work goals and to match procedures with situations, but they also have many other tasks (Woods & Cook, 1999):

- They resolve conflicts,
- anticipate hazards,
- accommodate variation and change,
- cope with surprise,
- work around obstacles,
- close gaps between plans and real situations, and
- detect and recover from miscommunications and misassessments.

With performing these tasks, it is possible to block trajectories that could have led to an accident. These people “actively contribute to safety when they can carry out these roles successfully.” (Woods & Cook, 1999) For people working in acute care, these different roles are even more important and are used very often, since their basic tasks are not static: every patient and situation are different.

People behave in, what can be considered, rational ways. Newell (1982) describes rationality as follows: “If an agent has knowledge that one of its actions will lead to one of its goals, then the agent will select that action.” (Newell, 1982) Sometimes, people make decisions that will lead to an accident. Why? And why does it seem that the same action in different cases sometimes leads to success and sometimes to failure (Woods & Cook, 1999)? Are they not thinking rationally at that moment?

No, but their rationality is bounded: “there are bounds to the data that they pick up or search out, bounds to the knowledge that they possess, bounds to the knowledge that they activate in a particular context, and there may be multiple goals which conflict.” (Simon, 1957, as paraphrased by Woods & Cook (1999)) Thus, rationality does not mean that judgement has to be consistent with external standards or procedures, but is defined locally “from the point of view of the people in a situation as they use their knowledge to pursue their goals based on their view of the situation.” (Woods & Cook, 1999). In other words, people do “what makes sense to them” (Dekker, 2006) at that moment. This is called local rationality.

With the limited information that is available on the case described in section 2.11 about the man with SAH, it is difficult to see and recognise the local rationality of the people that were there. An example from that case could be that the red rash that was discovered on the patient was explained as possibly being an allergic reaction. This seemed logical to the ambulance nurses, for the patient did eat a pizza after which the symptoms had started (they thought), and had vomited a couple of times. They ‘connected the dots’, and convinced the SEH doctor, who in turn administered treatment for an allergic reaction. After some time, it became clear that an allergic reaction was not the cause of the symptoms, but at that moment, it seemed at least very plausible to multiple practitioners.

When you look at error, and try to analyse it, it is important to find out why the actions people performed made sense to them. In some cases, the presence of conflicting goals is pushing people (unknowingly) to the ‘edge’. In the following subsection, it is explained how different goals or drivers contribute to boundary-seeking behaviour.

## **5.3.2 Psychological features of the person and organisation erring**

The people and organisations erring are ‘suffering’ from more psychological forces (just as any other person). In this section, the focus will be on how people cope with conflicting goals, whether people always follow procedures, and on human performance.

### ***Conflicting goals and boundary-seeking behaviour***

First of all, people working in acute care and in other safety-critical fields need to ‘juggle’ multiple goals at the same time (Dekker, 2006). They need to take care of the patients, as good as possible and quickly as possible – not only for that patient, but also to be available for other patients as soon as

possible, they need to be efficient, because the management has a limited amount of means and money to realise all goals, and they need to manage their own, personal workload. There are even more goals, depending on the situation: for example, ambulance personnel also has to deal with onlookers at the scene, that may not be very cooperative. Another example could be that medical personnel in the whole acute care system need to distinguish between acute and non-acute patients quickly and correctly, because non-acute patients clutter the system, but sending away acute patients will be a mistake and might lead to (permanent) health damage or even death. The safety goal of 'not making mistakes' is one of many, and is constantly competing with the other goals (Dekker, 2006).

Different goals push people in different directions. This causes people to move around in their own 'space of possibilities', their direction depending on the goals or pressures that are pushing most at that moment (Rasmussen, 1997). Rasmussen (1997) showed this behaviour in a figure similar to figure 5.2: on the right, the boundaries to economic failure and to unacceptable workload create forces towards efficiency and least effort. These are just two examples, but it is clear that these are at least partly conflicting. People tend to move around in the area between them, in the direction of the boundary defined by official work practices.

Official work practices – rules – are designed for “a particular task in isolation whereas, in the actual situation, several tasks are active in a time sharing mode.” (Rasmussen, 1997) As a consequence, rules, protocols, and instructions are practically never followed exactly. Looking at the workload caused by juggling all potentially conflicting goals, it is rational behaviour for people not to follow the official work practices (Rasmussen, 1997). Another problem that arises because of this, is the fact that – with the current way of handling errors – it is very easy to blame someone, because most probably, not all protocols were followed precisely. This will be discussed in the following subsection as well.

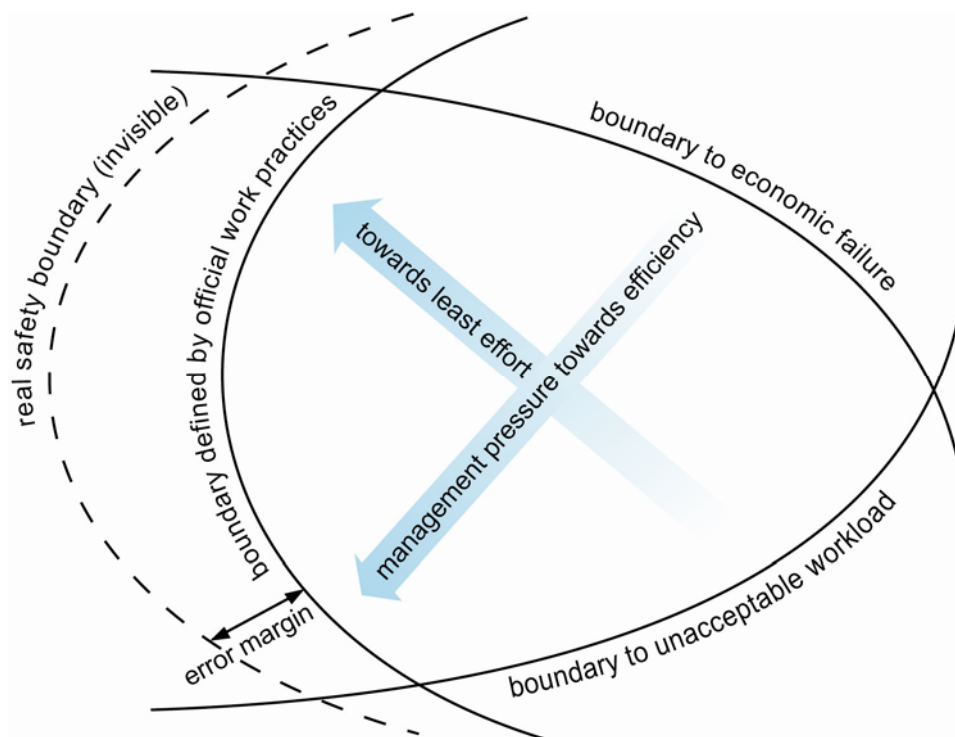


Figure 5.2: Model with workload and economic forces that push work practice towards – and beyond – the real safety boundary. Adapted from Rasmussen (1997) and Vicente (2006).

What happens in figure 5.2 is that people cross the boundary defined by official work practices, and then get in the small area called the 'error margin'. Once the real safety boundary is crossed, accidents occur. The problem is that it is unknown how large the error margin is, and where the real safety boundary is located. People can breach the rules set by official work practices every day (this means they are in the 'error margin' area) without an accident occurring (Rasmussen, 1997; Vicente, 2006).

Rasmussen (1997) also gives his vision of an approach to reduce the chances of error: “[A] promising general approach [...] appears to be an explicit identification of the boundaries of safe operation together with efforts to make these boundaries visible to the actors and to give them an opportunity to learn to cope with the boundaries. In addition to improved safety, making boundaries visible may also increase system effectiveness in that operation close to known boundaries may be safer than requiring excessive margins which are likely to deteriorate in unpredictable ways under pressure.” For acute care, this applies. Although it may be difficult to identify the safety boundaries explicitly and correctly, coping with the boundaries is the only effective way of dealing with safety in acute care, since there is no room for excessive margins: medical personnel needs to handle patients fast and thus under a lot of pressure. Under pressure, the margins will weaken, and excessive margins that are known to be excessive by the personnel will fail.

### ***Procedural drift***

Some aspects of organisations make people more prone to erring. Dekker (2006) explains procedural drift as being either violating or non-violating. Seeing procedural drift as violating means that people do not do what they are supposed to do (Dekker, 2006). Procedural drift can also be seen as non-violating: “even though actual performance may mismatch written guidance, people’s behaviour is typically in compliance with a complex of norms, both written and implicit.” (Dekker, 2006)

Deviations from the old norm can become the norm themselves: it is a gliding scale, in which people do not recognise that they are already far into the error margin (see figure 5.2).

### ***Human performance***

In safety-critical fields, human performance is (constantly) under pressure. The following mechanisms can occur, which may lead to error (Dekker, 2006):

- **cognitive fixation:** a misinterpretation of the situation, often ‘just doing something’ helps simplifying the diagnostic problem (which lowers cognitive stress), and consequently people justify their action by building an explanation that fits
- **plan continuation:** “sticking to an original plan while the changing situation calls for a different plan”
- **stress:** stress is seen as part of a situation, the cause of it, and the result of it. The most important features of stress are:
  - o demand-resource mismatch: people perceive a mismatch between the demands of the situation and their own resources of coping with that situation.
  - o tunnelling and regression: tunnelling is “the tendency to see an increasingly narrow portion of one’s operating environment.” This can be seen as dysfunctional, but it also is a coping strategy in very complex environments. Regression is “the tendency to revert to earlier learned routines even if not entirely appropriate to the current situation.”
  - o distortion of time perception: under high workload and stress, time perception can be heavily distorted which can be dangerous. For instance: “How long has the patient been without a clear airway?”
- **fatigue:** can be the result of workload, sleep deprivation, and time of day effects (think of night shifts). It can have several effects, such as: cognitive slowing, memory effects, and lapsing (micro sleeps of about ten seconds). One additional problem of fatigue is that it influences your own judgement of how fatigued you are.
- **buggy or inert knowledge:** people have knowledge which they use for their work. They have a mental model which contains gaps and mistakes. It is possible that people just do not possess the knowledge needed. Inert knowledge is another problem: in that case, the knowledge is there, but the person cannot reach it. This has to do with the organisation of the knowledge in the mental model: it needs to be ‘reachable’.
- **new technology and computerisation:** technology is omnipresent in safety-critical fields. It helps in performing difficult tasks, but also can cause problems, mainly related to insight into what the technology is doing, and related to handling the technology.
- **procedural adaptations:** people do not always follow the rules, just as was described earlier, but they adapt procedures to deal with the situation. Dekker (2006) also made a comparison between different ways of looking at procedures and safety. It is shown below in table 5.1:

Table 5.1: *Opposing models of procedures and safety, cited from Dekker (2006)*

<b>Model 1 (old view)</b>	<b>Model 2 (new view)</b>
Procedures are the best thought-out, safest way to carry out a task.	Procedures are resources for action (next to other resources).
Procedure-following is IF-THEN, rule-based behaviour.	Applying procedures successfully is a substantive, skilful cognitive activity.
Safety results from people following procedures.	Procedures cannot guarantee safety. Safety comes from people being skilful at judging when and how they apply.
Safety improvements come from organisations telling people to follow procedures and enforcing this.	Safety improvements come from organisations monitoring and understanding the gap between procedures and practice.

Dekker (2006) is clearly a supporter of model 2. Because of the complexity of safety-critical systems, people are key to safety. Procedures can help (for example in helping to cope with the situation), but are not sanctifying. They will always be limited, since reality is more versatile than can be anticipated.

Multiple of these human performance mechanisms can have influenced the series of events that occurred in the case about the man with SAH that was introduced in chapter 2, section 2.11. All actions described took place between 22:45h and early morning. This means that people were probably tired, perhaps had worked already for a long time, or just had started a night shift right after a busy week, etcetera. The practitioner answering the phone with the HAP was perhaps very busy, and under stress and due to that, suffered from distortion of time perception: why did it take so long before the call was returned? The registrar neurologist was working on the neurology department and also had to cover the neurological cases that were brought in at the emergency department: perhaps there was stress involved which may have influenced her actions.

### **Responsibility**

Some readers might think that all these arguments in favour of a different view on human error, are also a plea against responsibility for people's own actions. This is not the case. Accountability is important in safety-critical jobs, in particular when it is about the safety of others (Dekker, 2006). You cannot, however, hold people responsible for things they had no control over. Dekker (2006) provides a 'formula' in which the relationship between responsibility and accountability is explained:

$$\text{accountability} = \text{responsibility} + \text{requisite authority}$$

In other words: people can only be held accountable for an outcome of their work, when it was their responsibility and they had the authority over the actions and decisions that were necessary to get to that outcome. Dekker (2006) claims that everywhere, there are numerous mismatches between responsibility and authority. Such a mismatch means that people are responsible, for instance for the safe transport of a heavily injured person, but do not have the authority over actions that are necessary to get that patient to a hospital alive. This creates conflicts, as has been described above for the gap between procedures and practice.

But also when people have full authority, things can go wrong that are not necessarily their fault (Dekker, 2006):

- impacts can be outside the knowledge of the person
- decisions need to be made under high uncertainty and within limited time (so not time to further research the case before acting)

These aspects can easily be overruled by saying that 'this is part of their job'. Working under difficult conditions is their job, but is it their fault when they make this kind of mistakes? Blaming the person means that the system in itself is fine. This way, after a mistake the person is blamed and the case is closed – without looking for opportunities to learn from this mistake. This tactic is self-enforcing, for people will try to conceal mistakes for fear of being blamed. At that point, there is no possibility anymore for learning from the mistake, since the mistakes get covered up.

So, how should you deal with responsibility and accountability? Dekker (2006) suggests holding people accountable without exposing them to liability or punishment. They should give their account, literally, by telling their story. This story should be spread throughout the system: it will be a lesson for everyone reading the story. "Stories are easily remembered, [...] can be mapped onto current difficult

situations and matched for possible ways out. Incident-reporting systems can capitalise on this possibility.” (Dekker, 2006)

Of course, this does not apply to true 'bad apples': those wilfully acting against the safety of patients should be held accountable and be punished.

### 5.3.3 Psychological effects and the human-tech ladder

Below, findings from section 5.3 have been placed in the human-tech model. The findings are all aspects of human nature, and as such are on the right side of the figure. For each level, the findings are summarised.

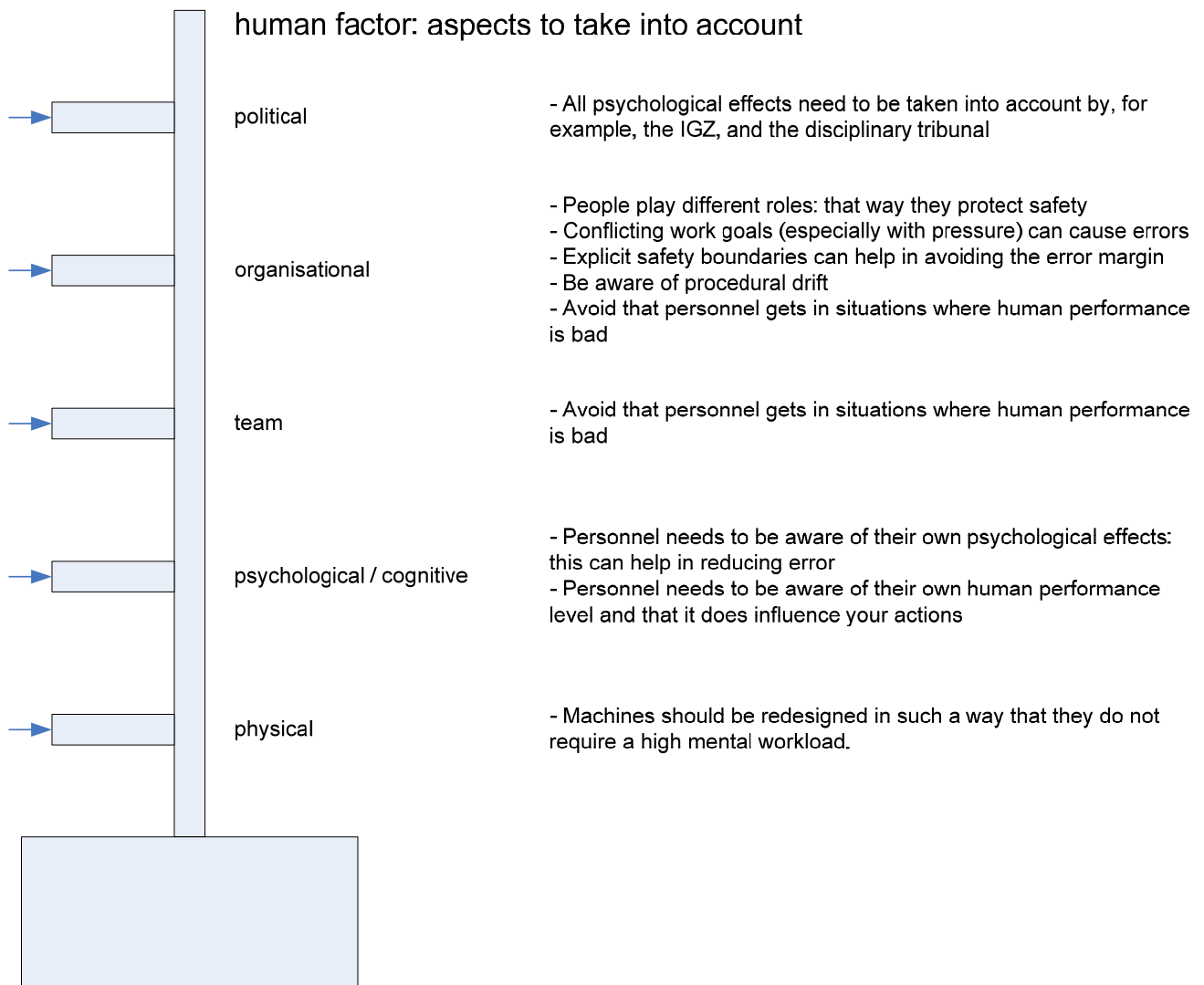


Figure 5.3: Part of the human-tech ladder – the human part – with findings from section 5.3.

### 5.4 Tensions in the acute care system concerning errors

There are a couple of characteristics of health care and the acute care system that are conflicting in different ways with the approach of handling errors that is presented in this chapter. Since these characteristics to a large extent determine the viability of this error handling approach, it is important to research them. In this section, three characteristics of both health care and the acute care system will be described.

### 5.4.1 Superhuman culture in health care

Medical personnel feel great personal responsibility for their actions and the outcomes (Dekker, 2006). The downside of this responsibility is that people think they can actually live up to it and not make mistakes. "To err or not to err is not a choice." (Dekker, 2006)

Medical personnel often works long shifts and a lot of hours per week. However, it is assumed they are physically and mentally capable of not making mistakes under these conditions. The content of their work is very safety-critical, which makes it even more important not to make mistakes. To work this way, requires 'superhuman' capabilities (Vicente, 2006).

Leape (1994) discusses the superhuman culture that pressurises people working in health care: "Physicians are expected to function without error, an expectation that physicians translate into the need to be infallible. One result is that physicians [...] come to view an error as a failure of character – you weren't careful enough, you didn't try hard enough. [...] It has been suggested that this need to be infallible creates a strong pressure to intellectual dishonesty, to cover up mistakes rather than to admit them. [...] Lessons learned are shared privately, if at all, and external objective evaluation of what went wrong often does not occur. [...] the perfectibility model: if physicians and nurses could be properly trained and motivated, then they would make no mistakes. The methods used to achieve this goal are training and punishment." (Leape, 1994)

Since the culture in health care is so much focused on the (super-)human side, it has been difficult for the medical world to embrace the human factor approach and the systems approach to human error: "After all, if you're supposed to be perfect, then there's no logical reason to embrace design changes. You should be able to achieve flawless performance, even if the technological system around you is poorly designed." (Vicente, 2006)

Sexton et al. (2000) conducted a survey about the attitudes of medical and aviation personnel concerning error, stress, and teamwork. The survey was conducted among anaesthetic, surgical, and intensive care nurses and doctors, and pilots. A remarkable outcome is the response to the following statement: "Even when fatigued, I perform effectively during critical phases of operations/patient care." Of the different nurses, 55 to 64% agreed. Of the doctors, 47 to 70% agreed. Of the pilots, only 26% agreed that fatigue did not really influence their performance.

Another statement was: "My decision making ability is as good in medical emergencies as in routine situations." While of most types of nurses, doctors, and pilots, about 60% agreed, intensive care personnel judged themselves very capable of making decisions in emergency situations: of the nurses, 84% agreed, and of the doctors even 90% agreed to this statement. Also, the study showed that a third of intensive care personnel claims they do not make mistakes (Sexton, Thomas, & Helmreich, 2000).

Their main findings were that medical staff is more likely to deny the effects of fatigue, compared to aviation staff; and that error is a difficult topic to discuss in the medical world. Not all medical personnel accept "personal susceptibility to error" (Sexton, et al., 2000).

The superhuman culture in health care may seem arrogant, but medical personnel just gets educated with this idea: "We get taught in medical school from day one that we can't make a mistake because otherwise we might kill people." (Poulson, 2002, as cited by Vicente (2006)) This implies that changing the culture of medical personnel into a culture where errors will not be seen (solely) as personal failure cannot and will not be easy.

### 5.4.2 Educational levels, functional independence, and scientific acting

Since the enforcement of the Zorgverzekeringswet (Health Insurance Act) in 2006, a new criterion for acting in line with scientific knowledge and practice was introduced for all forms of care. The 'criterium stand van de wetenschap en praktijk' (literally: criterion state of the art (science) and practice), determines that all care provided should comply with what is tested and found reliable by medical science, and/or should comply with what in that field of work is seen as adequate (College voor zorgverzekering, 2007).

Almost all medical personnel working in the acute care system are nurses. Besides general practitioners, doctors are only part of special trauma teams and work in the emergency departments of hospitals. This means that, although ambulance nurses and triage nurses have a professional nursing degree and received special training geared towards their line of work, they do not have a medical degree. For them, it can be difficult to comply with changing state of the art knowledge on the enormous number of acute illnesses.

Even with this possible knowledge problem, ambulance nurses do have functional independence, that is, they are by law allowed to perform some specific, dangerous medical actions. These actions, called 'voorbehouden handelingen' (restricted actions), are usually only allowed for doctors, since these actions have high risks. A Ministerial Order determined in 1997 that ambulance nurses are allowed to perform the following actions without supervision or assignment from a doctor (Besluit functionele zelfstandigheid):

- applying elective cardioversion, direct current defibrillation to regulate the pulse;
- applying defibrillation
- in- or extubate the trachea
- applying a drainage puncture in the case of valvular pneumothorax
- performing a coniotomy: making an incision through the skin of the throat to secure the airway

These actions can have a large impact on the patient: of course, they are performed to save the patient's life (all actions are related to heart and lung functions), but when performed in the wrong way they can have grave consequences. Therefore, it is important that ambulance nurses are kept informed of the state of the art concerning these actions, but also about the acute illnesses they have to deal with, as is described in section 2.5.

### **5.4.3 Error awareness and feedback from the system**

Another tension that becomes important when we want to look at errors within the acute care system concerns error awareness. Medical personnel either become aware of an error at that moment, while they are still with the patient, or they hear about it later. A third option is that they do not hear anything about the error: they never found out it occurred, which means it can recur.

Currently, feedback from the system – what happened to a patient in the end – is very limited. The feedback is not structural and only comprises very difficult cases that drew a lot of attention to them, for example because it became a disciplinary council case. Since a couple of years there are ROAZ ('Regionaal Overleg Acute Zorg', regional consultation acute care), which are meant to create exchange of knowledge between different care providers, and to make sure they become more attuned to each other, to improve coordination, cooperation, and quality of care (Klink, 2008). In practice, these ROAZ do not seem to be talking about very concrete issues (Berden, 2008).

The problem that emerges from this behaviour is that medical personnel do not know the whole story, with at least one consequence: that they miss the opportunity of realising that they made a mistake. When in hindsight it appears that the chosen treatment was incorrect (either being not beneficial or even damaging), medical personnel does not hear about it, depending on the outcome. Of course, when severe health damage occurred because of their actions, they will hear from it through investigations, but there are other possibilities as well. It appears that currently the following things can occur:

- the treatment was beneficial, but no feedback to hear that it actually was
- the treatment was neutral: not beneficial, but not damaging either, no feedback
- the treatment was damaging, no feedback
- the treatment was damaging, feedback (sometimes in the form of an official investigation)
- regardless of the outcome, informal feedback from other medical personnel down the chain

In order to learn from error, especially also when it did not lead to (great) damage, there needs to be error awareness. This means that, besides the different culture as discussed in 5.4.1, more feedback is needed throughout the system.



## 5.5 Conclusions about human error

In this chapter, the human factor approach has been used to create a way of looking at the performance of the acute care system. By looking at errors, it is possible to find flaws in the system. When an error occurs, often people will be blamed for it. This suggests that the complex system around them is otherwise safe and well-functioning. In health care, this approach is dominant.

The human factor view on human error sees human error as a symptom of a problem deeper inside the system. Well-intentioned people are compromised in their pursuit of success, because of imperfect features of the system they have to work in (Dekker, 2006; Woods & Cook, 1999). Rather than concluding with blaming a person, one can learn from finding the system failure. Errors are made by everyone, not only by 'bad apples' and errors tend to recur: patterns can be found when looking at errors. Applying a system approach can prevent errors in the future, by giving insight into the causes that are not immediately apparent.

There are several (psychological) features of the analyst, the person, and the organisation erring. This chapter to here has covered:

- outcome bias
- hindsight bias
- local rationality
- boundary-seeking behaviour because of multiple, conflicting goals
- procedural drift, change in norms
- human performance mechanisms:
  - o cognitive fixation
  - o plan continuation
  - o stress
  - o fatigue
  - o buggy or inert knowledge
  - o new technology and computerisation
  - o procedural adaptations

Accountability is important in safety-critical jobs, in particular when it is about the safety of others (Dekker, 2006). People can only be held accountable for an outcome of their work, when it was their responsibility and they had the authority over the actions and decisions that were necessary to get to that outcome.

Also when people have full authority, things can go wrong that are not necessarily their fault (Dekker, 2006). Blaming the person means that the system in itself is fine. Dekker (2006) suggests that we deal with responsibility and accountability by holding people accountable without exposing them to liability or punishment. Of course, this does not apply to true 'bad apples': those wilfully acting against the safety of patients should be held accountable and be punished.

There are a couple of characteristics of health care and the acute care system that are conflicting in different ways with the approach of handling errors that is presented in this chapter: the superhuman culture in healthcare, that causes people to think they 'just do not make mistakes', even under difficult situations, and when being fatigued. The educational levels of most people in the acute care system can be conflicting with working according to state of the art knowledge about illnesses and treatments. Finally, error awareness is crucial point for the success of learning from error analysis: without people being (made) aware of errors, there are no errors to analyse. Besides a different culture towards error, more feedback is needed throughout the system.

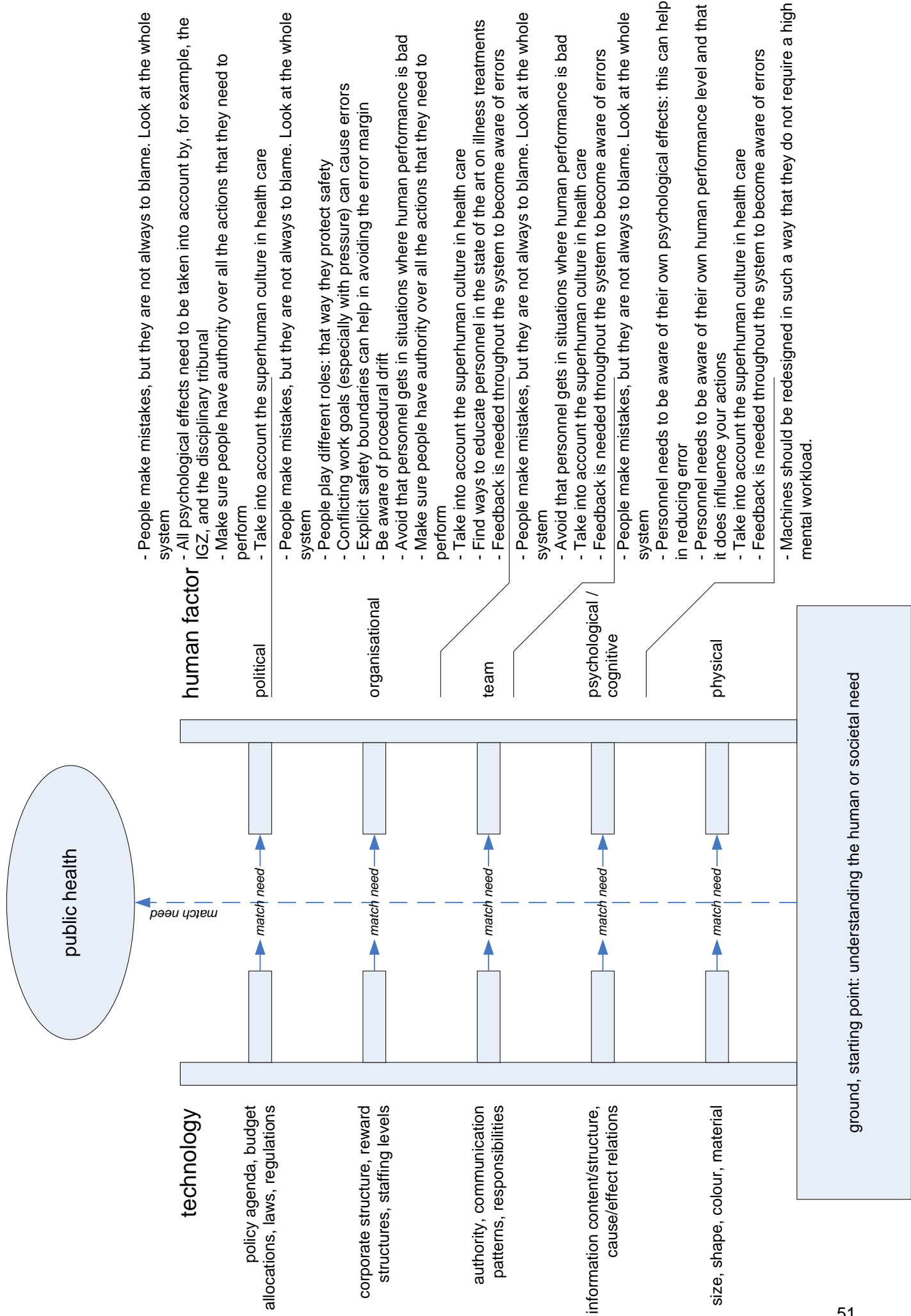
On the next page in figure 5.4, the human-tech ladder is displayed again, now with all findings from this chapter to this point. All these aspects are of importance when analyzing and judging errors within the acute care system.

Is this approach new? Combining the human factor approach with human error knowledge is not completely new: for example, Vicente (2006) used many errors to show what goes wrong in complex systems. It is new, though, to use specific information on human nature to make a roadmap for system innovation. This 'roadmap' will be discussed in chapter 7. The methodology used to gather this information has added value, for systems analysis and policy analysis would not directly provide a focus, a way of looking specifically at the system, and the human factor approach does: the human-

tech ladder shows that details on these five levels are necessary if you want to reach the top goal: public health, and defines where to look: the human factor approach is thus also a guide that leads you through the different human factor levels of the system.

In the following section, the human factor approach towards human error will be reviewed in other systems than acute care. The way the human factor approach was implemented in the following case studies can be used to learn from for the roadmap in chapter 7. It can also show whether the human-tech ladder is a usable tool in other sectors.

*On the following page: figure 5.4: The human-tech ladder with all findings of chapter 5 to here.*



## 5.6 Learning from error: learning organisations in safety-critical fields

We studied the system characteristics of error, and the biases and other aspects of human nature that need to be taken into account when analysing error, but the ultimate goal is to learn from these errors and to improve the system, to prevent new errors from happening. This should 'become a habit': learning organisations use the errors that occur to become better organisations.

Currently, most health care organisations are not learning organisations (Vicente, 2006). Errors are handled by disciplining medical personnel: by this, two effects are in place:

- The personnel making mistakes are removed from the system. This should lead to a better system with less errors.
- All personnel have a fear of making mistakes, because it will lead to disciplinary measures. This should prevent people from making mistakes.

In the previous sections, it has been shown that this method does not work. To recapitulate: first of all, it is not the 'bad apples' making all mistakes, but everyone is 'capable' of making mistakes. You lose personnel by disciplining them, and the system does not really improve, since all other personnel are just as prone to making mistakes. Second, the fear of making mistakes cannot be healthy for your workload, it will not prevent anyone from making mistakes (perhaps it even increases the chances of making mistakes due to higher stress levels), and people will try to cover up mistakes (Vicente, 2006). Finally, what do you gain from the error? The system does not improve on its own.

To change the system in such a way that it can improve with the help of 'error information', the organisations within the acute care system need to become learning organisations. A learning organisation is "an organization that facilitates the learning of all its members and continuously transforms itself" (Pedler, Burgoyne, & Boydell, 1997, as cited by Wikipedia (2009)).

### ***Making recommendations: there are no easy fixes***

Making recommendations is not easy. When researching errors in the acute care system, it can seem as if only simple, 'shallow' measures are available, such as (partly based on Dekker (2006)):

- Reprimanding the practitioner involved
- Obliging the practitioner involved to get additional training
- Making a new procedure for handling this specific situation in which the error occurred
- Warning other practitioners for this specific situation
- Adding technology to 'help' the practitioner

All these measures are relatively easy to implement, but they are likely to have a small effect: an effect on only that particular practitioner is not that large, and warning other practitioners will have a short-lasting effect. Setting an example by reprimanding erring practitioners can even have a counterproductive effect, see the next sub section. Drawing up new procedures is likely to clutter the maze of procedures the practitioners already have to deal with. Finally, adding technology might introduce new errors, because of malfunctions, or because it hides information from the practitioner (for example, the practitioner leaves the decision up to the machine, while in fact, the machine is not capable of assessing the situation correctly).

Dekker (2006) shows the relation between the effort of implementation of a measure and the effect in the figure 5.5 below. The high-end recommendations cover higher parts of the human-tech ladder, which results in a longer-lasting, greater effect.

There are many difficulties to overcome, though, in order to implement a high-end recommendation. First of all, it may be difficult to understand the system and to see what should change to improve it. Second, it may be hard to convince others that this recommendation is useful. According to Dekker (2006), often heard objections are (based on Dekker (2006)):

- We already pay attention to that
- That is in the procedures/guidelines
- It is not our role to do that
- This recommendation is not relevant to the error
- It is not our problem

For all of these objections, it is important to counter them effectively: proof is needed.

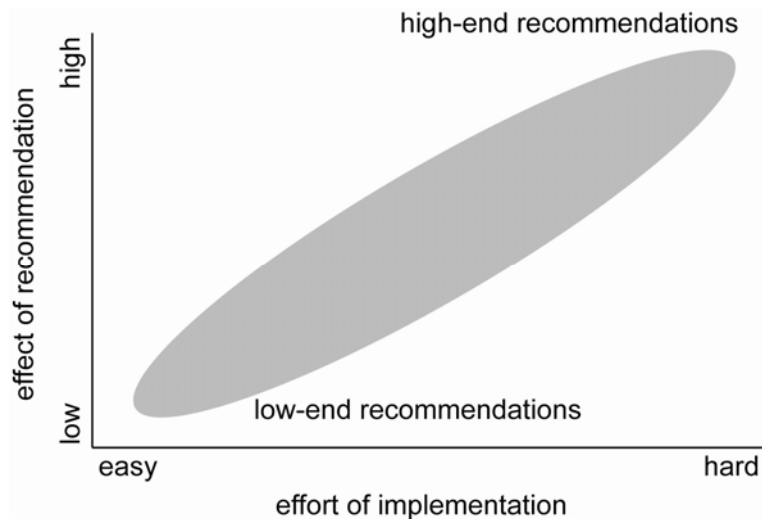


Figure 5.5: Relation between the effort of the implementation of a recommendation and the effect of it (Dekker, 2006)

### **Blaming and shaming**

The blaming and shaming that are common practice in health care have been described before (see sections 2.9, 5.3, and 5.4). It also has been concluded that punishing the practitioner probably will not solve the real problem: actually, as Vicente (2006) puts it: it only makes things worse, because the threat of being punished can even cause errors. The superhuman culture in health care (see section 5.4.1) causes people to think that one is able to not make mistakes, but this is not true, and blaming and shaming will not help in clearing up this 'misunderstanding'.

### **Quantifying quality by counting errors?**

Quantifying quality by counting errors is often tried. The problem lies herein: it is not clear what an error exactly is (Dekker, 2006). Systems and behaviour of the people in it are too complex and fuzzy to distinguish 'erroneous decisions', and there is no agreement on what an error is: the definition and whether people count it as an error are dependent on personal perception (Dekker, 2006).

The original idea behind counting errors is that the number of errors says something about the quality of the system. In the previous subsections, however, it has been discussed that – perhaps even more important than the occurrence of the error – the local rationality is key to understanding error. When counting errors, you miss out on that valuable information that could actually help in reducing the (number of) errors.

## **5.6.1 Looking at other safety-critical fields**

Looking at other fields that deal with quick decision-making, inter-organisational cooperation, and large risks might help in finding ways to changing the organisations into learning organisations. Safety-critical fields, such as aviation and nuclear power generation, can be used to learn from. In these fields, high reliability organisations operate. High reliability organisations are organisations where "a high degree of functioning reliability is required to fulfil its intended purpose and where the margin for error is small. Even the slightest error can have catastrophic and costly results." (Rampersad & Rampersad, 2007)

Reason (2000) discusses how health care can learn from other safety-critical fields. He ends his paper with this strong conclusion:

"High reliability organisations are the prime examples of the system approach. They anticipate the worst and equip themselves to deal with it at all levels of the organisation. [...] For these organisations, the pursuit of safety is not so much about preventing isolated failures, either human or technical, as about making the system as robust as is practicable in the face of its human and operational hazards. High reliability organisations are not immune to adverse events, but they have learnt the knack of

converting these occasional setbacks into enhanced resilience of the system.”  
(Reason, 2000)

But is it possible to translate directly from other fields to acute care? Reason (2004) points towards a couple of important differences:

- The operations and equipment are very diverse, compared to for example aviation, where a pilot is only allowed to fly one type of airplane (in 't Veld, 2009)
- The frequency of emergencies is very high, compared to for example aviation. While emergencies in health care happen on a daily basis, in aviation, emergencies are quite rare. To give an indication, a presentation of emergencies that resulted in fatal accidents: in 2008, there were worldwide 12 aircraft accidents involving fatalities among passengers. The total number of passenger fatalities was 455. Only one passenger died every  $9.09 \cdot 10^9$  passenger-kilometres (International Civil Aviation Organization, 2009).
- The degree of uncertainty is much higher than in for example aviation: an airplane is much more predictable than the human body, and – since the crew knows the airplane – they are prepared for what can happen to it. Compare this to a doctor, who does not know the patient, nor his body, nor the (hidden) ailments that are present.
- Patients are very vulnerable, compared to for example nuclear power plants. The latter ones are protected with numerous redundant barriers to prevent accidents.
- Health care is very personal: care is usually provided from one medical practitioner to one patient. This means that the (single) practitioner in situ has a large influence on the outcomes. Compared to aviation, this is remarkable. In an airplane, all actions are heavily automated and moderated by other members of the crew. (Reason, 2004)

Below, a number of cases is described from anaesthesiology and aviation. The goal of these cases is to show that systems and organisations can adopt a way of reporting errors and dealing with that information in such a way that they become better systems. There is also a focus on the historical development of the reporting systems. For every case, first a comparison is made between acute care and the other field, to show what similarities can be used to learn from, and what differences need to be taken into account. In section 5.5.4, the cases will be evaluated: what can the acute care system learn from these other systems?

## 5.6.2 Case: error analysis in anaesthesiology

Of all medical fields, anaesthesiology is probably most geared towards the human factor approach to date. The quality of anaesthesiology increased immensely. Vicente (2006) mentions the following statistics: “In ten years time, the chances of dying from anaesthesia went from about one in 10,000 or 20,000 to less than one in 200,000.” According to Vicente (2006), the cause for this improvement was the focus on human psychology.

There are a couple of differences between the acute care system and anaesthesiology. These are listed in table 5.2 below. These differences need to be taken into account when looking at the possibilities of transplanting (parts of) the reporting system of aviation to acute care.

*Table 5.2: Differences between acute care and anaesthesiology*

<b>Acute care</b>	<b>Anaesthesiology</b>
The acute care system consists of emergencies	Anaesthesiology has a mix of work, though most of it is planned
The patient and its medical history are unknown to the medical practitioner	In the planned cases, the patient is already familiar, so some anaesthesiological risks can be eliminated
Acute care practitioners have to work ‘in the fields’	Anaesthesiologists usually work in operating theatres, where everything is close at hand and attuned to the work that has to be done

In anaesthesiology, the first steps on the ‘human factor route’ were already made during the late 1970s, when anaesthesiologists were asked to describe critical incidents. The critical incident technique was developed by Flanagan in the 1950s for aviation incidents (Cooper, Newbower, Long, & McPeck, 1978; Vicente, 2006). The following definition of ‘critical incident’ was used: “A mishap was labelled a critical incident when it was clearly an occurrence that could have led (if not discovered or

corrected in time) or did lead to an undesirable outcome, ranging from increased length of hospital stay to death or permanent disability.” (Cooper, et al., 1978) They were also asked for the circumstances under which the incident occurred (Cooper, et al., 1978; Vicente, 2006). Over 350 ‘reports’ were drawn up and analysed. They concluded the following:

“Most of the preventable incidents involved human error (82%), with breathing-circuit disconnections, inadvertent changes in gas flow, and drug syringe errors being frequent problems. Overt equipment failures constituted only 14% of the total number of preventable incidents, but equipment design was indictable in many categories of human error, as were inadequate experience and insufficient familiarity with equipment or with the specific surgical procedure. Other factors frequently associated with incidents were inadequate communication among personnel, haste or lack of precaution, and distraction.”

Because of the great uncertainty and risks that health care has to deal with, Cooper et al. (1978) also had additional requirements for selecting critical incidents: “Many complications of anaesthesia are not ‘preventable’ given the finite limits of medical knowledge. The incidents considered here are those where the anaesthetist clearly failed to follow accepted practice or where a piece of equipment ceased to function normally. When doubt existed about preventability, the incident was excluded.” This is very important, since emergencies occur so often in health care, while sometimes there was no way of preventing it.

What was perhaps most important of this study – and of other similar studies that followed – is that they provided material with which the system could be improved. The paper of Cooper et al. (1978) proved to be very influential.

When we combine the findings of the study by Cooper et al. (1978) with the human-tech ladder, it is clear that the introduction of an innovation like the use of the critical incident technique that acknowledges the human factor on different levels, can lead to more innovations. See figure 5.6 below.

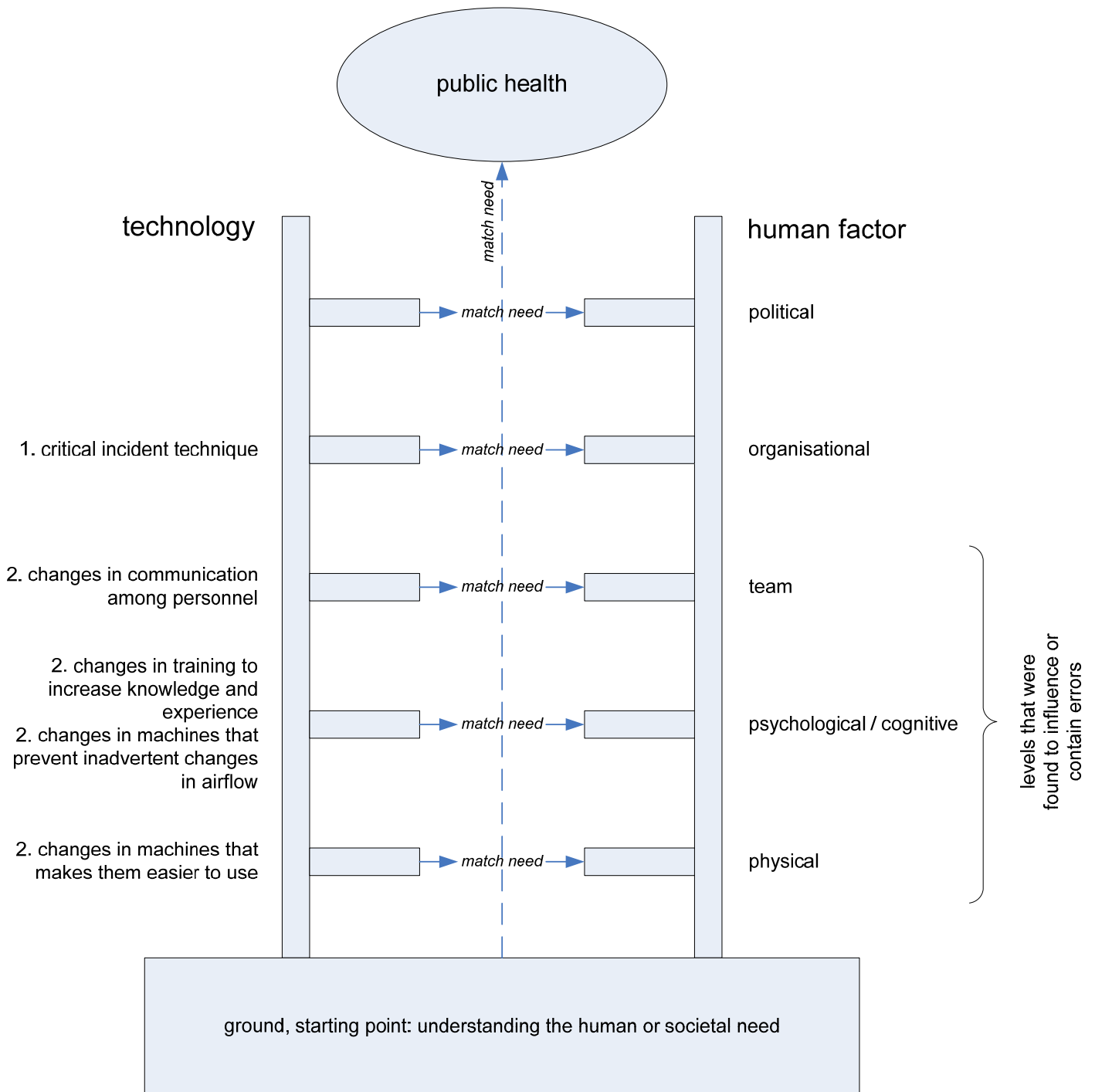


Figure 5.6: The human-tech ladder with the introduction of the critical incident technique in the field of anaesthesiology (1), and the innovations on different levels that resulted from the findings (2). On the right, the levels that were involved in the occurrence of errors are marked here (this is on the basis of the research findings by Cooper et al. (1978), and does not have to be complete).

### 5.6.3 Case: the Aviation Safety Reporting System

At the dawn of aviation, flying was very dangerous. Many accidents occurred, most often with fatal outcomes. The two world wars pushed innovation, technically (the invention of radar, for example), but also in the field of human-machine interaction. In military aviation, for the first time research was conducted to find what should be changed in airplane design to reduce the amount of accidents, with success (Vicente, 2006). Now, aviation is a very safe field.



Below, a couple of differences between acute care and aviation are listed in table 5.3. These differences need to be taken into account when looking at the possibilities of transplanting (parts of) the reporting system of aviation to acute care.

*Table 5.3: Differences between acute care and aviation*

<b>Acute care</b>	<b>Aviation (in 't Veld, 2009)</b>
The acute care system consists of emergencies	Aviation only rarely has emergencies
Patient is central, at risk, but not in charge	Pilot is central, at risk, and in charge
Patient is not an expert	Pilot is an expert
Every patient is different	A pilot only operates one type of airplane
The patient body is vulnerable and non-redundant	The airplane is more robust and has redundancies
The patient body is already 'malfunctioning' and the goal is to get it to function again. This makes it more difficult to say a medical practitioner made a mistake: what would otherwise have happened?	The airplane is usually functioning, and mistakes can be made when there is a malfunction that should be solved, or the pilot creates a malfunction.
It is possible to change a way of working in just one small district to see if it works	It is impossible to make large changes to test something, since then the worldwide aviation system needs to be adapted to that change

In 1956, the U.S. Civil Aeronautics Board (an agency responsible for safety rulemaking, accident investigation, and economic regulation of the airlines (U.S. Centennial of Flight Commission, 2003)) noted the increase in near-collisions in the air and wanted to investigate this phenomenon. In order to gather more information on this, they adopted a regulation that granted "immunity from disciplinary proceedings to pilots reporting near misses." (Federal Aviation Administration, 1997) This meant that the identity of the person, reporting voluntarily, would stay confidential. However, when information on that same near miss was obtained in another way, the person would not be protected by his earlier report (Federal Aviation Administration, 1997). In 1959, the near miss reporting program was ended, because reportedly, there was no use for it anymore (Federal Aviation Administration, 1997). The future reporting of near misses was transferred to the Federal Aviation Administration (FAA), who already handled all other safety violation reports.

Both in 1961 and 1968, the FAA performed surveys of near-collisions in the air during one year and two years respectively. The identities of the people reporting was protected by the FAA. The 1968 study was extended for another two years. By the end of 1971, the study ended, and so did the immunity policy (Federal Aviation Administration, 1997).

In 1975, the Aviation Safety Reporting Program was established in order to gather information on 'potentially unsafe conditions' (Federal Aviation Administration, 1997). This program granted "immunity from disciplinary actions to pilots or controllers who filed a timely report. No immunity was granted, however, in the case of 'reckless operations, criminal offenses, gross negligence, wilful misconduct, and accidents.' FAA remained free to take corrective or remedial action necessary for air safety." (Federal Aviation Administration, 1997) This was the first program that had a broader focus: it was not limited to reports of near-collisions in the air.

This system had been set up and evolved with the idea of learning from near misses, but the system was not used a lot (Vicente, 2006). The problem here was the system: why would you report an incident to the FAA, while the FAA is also the organisation responsible for handling safety violation reports, and thus handing out fines and reprimanding people. Of course, the FAA granted immunity to people reporting, but this was not the case when 'reckless operations' or 'gross negligence' were at play. But who decides that? The incentives for people to actually report were very small. First of all, it can be questioned whether the FAA truly can keep confidentiality of the identity of the people reporting within their organisation. Second of all, if the FAA decides on the basis of a report, that the person was behaving recklessly, for example, that person will be reprimanded, while s/he was trying to prevent other people from making the same mistake again. This called for change.

The Air Line Pilots Association was also sceptical about the Aviation Safety Reporting Program, mainly because of the above mentioned reasons, and preferred a different system, in which a third party would process the reports and would really protect the identity of the people reporting. By the

end of 1975, the FAA agreed and announced that NASA would implement a “system for processing reports of aviation hazards and safety-related incidents while preserving the reporters’ anonymity” (Federal Aviation Administration, 1997) Starting April 1976, NASA got the following tasks (Federal Aviation Administration, 1997):

- receive and process reports;
- delete information that would reveal the identity of the informants;
- analyse and interpret the data;
- provide the results to FAA and the aviation community, in the form of a newsletter ‘Callback’, a journal ‘ASRS Directline’ and through research studies; and
- send information concerning criminal offenses directly to FAA and the Justice Department

The FAA changed their policy to implement the involvement of the NASA: “Under the new policy, FAA would waive disciplinary action against all those involved in an incident provided a timely report was filed with NASA and certain other stipulations were fulfilled. FAA would not use reports for disciplinary purposes even if they involved reckless operation, gross negligence, or wilful misconduct (although disciplinary action might be taken in such cases on the basis of information obtained independently). As before, no form of immunity was provided in cases involving accidents or criminal offenses, and FAA remained free to take remedial action to ensure safety.” (Federal Aviation Administration, 1997)

To date, more than 715,000 reports have been submitted to the ASRS database, about 40,000 a year (NASA/ASRS, 2009; Vicente, 2006). All reports are de-identified, and no longer contain names (of people and organisations), dates, times, and other related information. According to the NASA, no identity has been breached during these years (NASA/ASRS, 2009). The system costs about US\$2 million annually to operate (Vicente, 2006).

The analysis of the reports is being conducted by experts, usually retired pilots. This is very important for the value of the information that is being put into the database. Their extensive knowledge makes sure that researchers can find a lot of information in the database that can be used for looking for patterns or trends. The information is also used by R&D departments of aviation organisations to improve their aircraft and systems. (Vicente, 2006)

The ASRS newsletter, Callback, is distributed monthly and covers a couple of reports or common problems. In the newsletter, different ways of dealing with such a problem are discussed. Vicente (2006) mentions another benefit of the newsletter: it shows people that (their) reports are used, that their story is being listened to, and it can motivate others to come forwards and also report their experience.

To summarise, the basic principles of ASRS are that it is:

- confidential
- voluntary
- non-punitive

Besides that, based on ASRS, prerequisites for a functioning reporting system are:

- independent organisation (not related to supervising bodies with reprimanding power)
- in depth analysis of reports by experts
- dissemination of findings; to make the field progress, and to show that ‘people are listening’

It took many years to find a system that works, but the ASRS in its current form is a success: “[The] success enjoyed by the ASRS shows that many lives can also be saved by deliberately creating a system of harmonious, interconnected relationships that allow people to learn from experience, while accommodating the difficulties of how people actually behave at an organisational level. Once again, it’s all about people.” (Vicente, 2006)

If we place the characteristics and outcomes of the ASRS in the human-tech ladder – see figure 5.7 – it becomes visible that the system itself is generating ‘leads’ for new innovations.

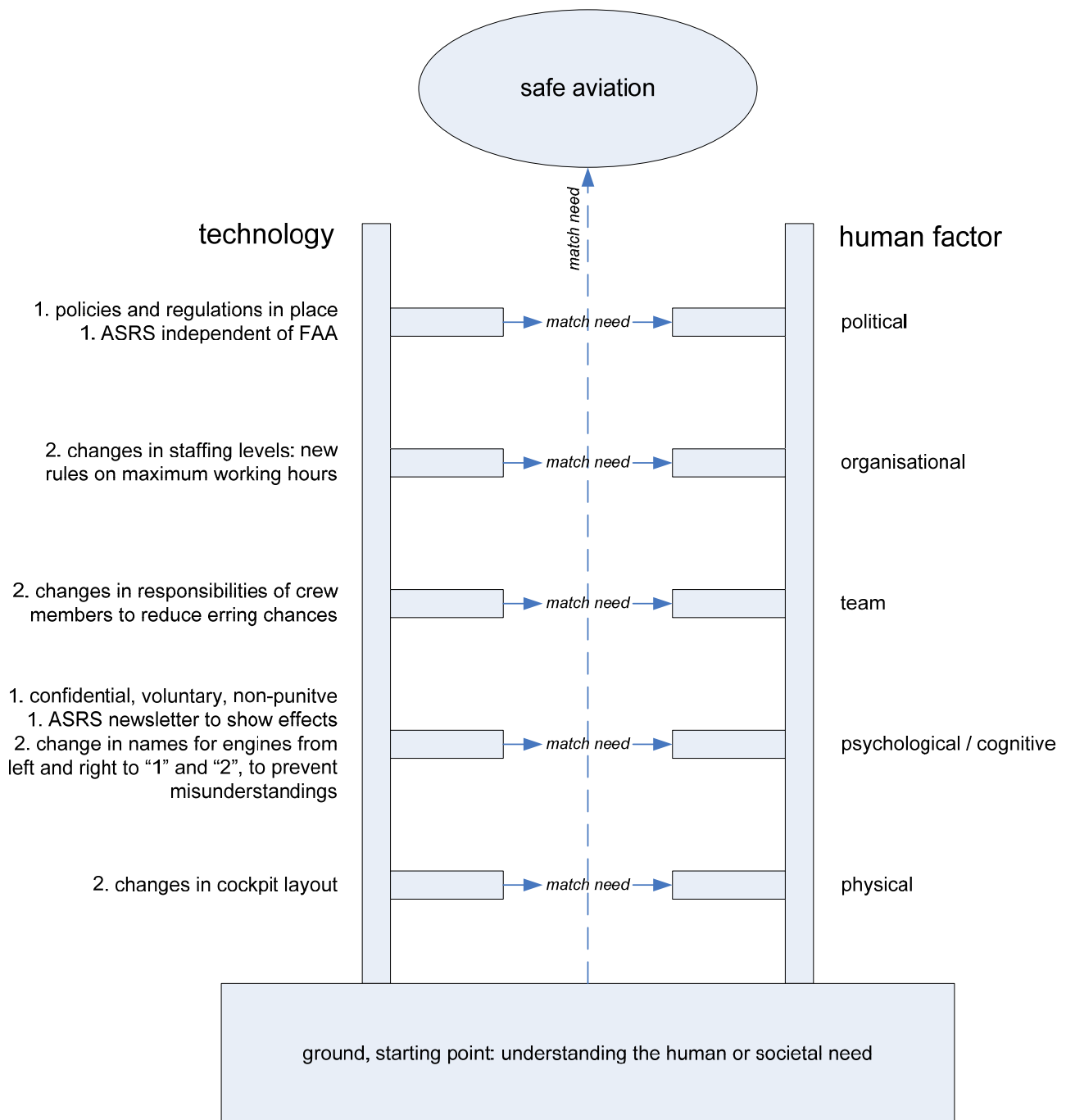


Figure 5.7: The human-tech ladder on the basis of the ASRS. The 'initial' innovation – the introduction of the ASRS – consisted of different parts on different levels, marked with '1'. The ASRS resulted in many more innovations. A couple of examples are given here, marked with '2'.

### 5.6.4 Lessons from the cases

The differences between the fields of acute care, aviation, and anaesthesiology are large, but lessons can be learned. The anaesthesiology case was mostly about the practical side of error analysis. It showed an example of the critical incident technique, which is used to ask about both the incident, and the circumstances that were present. Cooper et al. (1978) only included incidents that were preventable: the fact that very often in health care, incidents are not preventable due to the high uncertainty, is important.

The study by Cooper et al. (1978) was also a success because it showed very clearly to other anaesthesiologists on what fields improvement was necessary, and as such provided them with a roadmap to safer anaesthesiology.

From the ASRS case, it becomes clear that the policy framework for a reporting system is complex. In the ASRS case, it took a long time before it worked, mainly because there were no positive incentives for aviation personnel to report.

The main 'ingredients' for an error safety reporting system, based on ASRS are:

- confidentiality
- voluntary participation
- non-punitive system
- the processing organisation must be an independent organisation (not related to supervising bodies with reprimanding power)
- in depth analysis of reports by experts is necessary
- dissemination of findings in different ways and to a broad audience is necessary; to make the field progress, and to show that 'people are listening'

It is also important that the policies 'fit in' with already present laws, regulations, and other regulating bodies.

The use of the human-tech ladder in depicting both cases shows that the ladder can be used in different fields, and thus is not limited to the acute care system.

## **5.7 Conclusion**

The main focus of this chapter was the human factor approach and how to deal with error. Section 5.1 to 5.4 have introduced a number of psychological concepts and characteristics of the acute care sector. The outcomes, summarised in 5.5, will help in setting up the roadmap for system innovation.

In section 5.6, lessons have been learned about learning organisations and about the specific cases from anaesthesiology and aviation. The human-tech ladder has been tested successfully as a tool for showing innovations on different levels. In chapter 7, the use of the human-tech ladder will change: then it will become guiding, rather than describing. But first, in chapter 6, the focus will be on quality.

## 6 Quality of health care systems: defining quality on different levels

This chapter focuses on the complex, multiform characteristics of quality of care in order to be able to discover the necessary focus of innovations to improve quality. The different levels of quality are arranged in a framework based on Donabedian and Campbell et al.

The RIVM proposed a set of performance indicators that could be used to 'measure' quality, but in section 2.9 it has already been argued that these indicators give a 'shallow' view of the performance of the system: the indicators are only about the operational actions. Operational actions are only on the individual levels of the human-tech ladder: physical and cognitive / psychological, and thus not cover all levels of the ladder, while all those levels do influence the quality of acute care. An other approach is needed.

In this chapter, the focus will first be on what health systems and quality are in sections 6.1 and 6.2. In section 6.3, a framework is presented that covers multiple aspects and multiple levels of quality of care. Conclusions are drawn in section 6.4.

### 6.1 The classification of a health care system

Donabedian (1988) distinguishes three classification categories within a system: structure (resources, methods), process (giving and receiving care: implementation), and outcome (the effects of care). These three categories should have relations (causal links): a good structure should lead to a good process which, in turn, should lead to a good outcome (Donabedian, 1988). Campbell et al. (2000) suggest that the structure and outcome categories are not parts of care, but the "conduit through which care is delivered and received" (Campbell, et al., 2000) and the consequences of care respectively.

### 6.2 Definition of quality

Of 'quality' multiple definitions exist, either generic or disaggregated (Campbell, et al., 2000). An example of a complex generic definition of quality was put forward by the US Institute of Medicine: "[the] degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge" (Lohr, 1992). Generic definitions of quality are usually hard to operationalise and, as Campbell et al. (2000) argue: "trade both sensitivity and specificity for generalisability". Disaggregated approaches take into account the complexity and multidimensionality of quality by defining several dimensions or components (Campbell, et al., 2000).

Donabedian (1988) argues that first of all, before talking about quality, the level of performance, types of quality, and all other boundaries need to be defined. Campbell et al. (2000) use two viewpoints in their analysis: quality of care for individual patients and quality of care for populations.

### 6.3 Quality frameworks for patients and populations

Campbell et al. (2000) describe two main dimensions for quality of care for individual patients: access (do users get care they need) and effectiveness (does the care they get have the intended result). These dimensions and the three categories of the acute care system form a framework that shows the quality aspects for individual patients in table 6.1. These aspects all have to be evaluated for individual patients, since for every patient, the situation is different. When looking at the quality of care for populations, the focus often is on optimizing health benefit for the population on average, while this may conflict with the quality of care for individual patients. The 'social' quality of care emphasises the net utility for the population (Donabedian, Wheeler, & Wyszewianski, 1982). Campbell et al. (2000) propose three additional sub dimensions for quality of care for populations: equity, efficiency, and cost, see table 6.2.

Table 6.1: Quality framework for patients of the acute care system, based on Campbell et al. (2000)

quality	acute care system		
	structure	process	outcome
accessibility	geographic/ physical access affordability availability	affordability availability	health status user evaluation
effectiveness		effectiveness of different parts of process	health status user evaluation

Table 6.2: Quality framework for populations of the acute care system, based on Campbell et al. (2000)

quality	sub dimensions	acute care system		
		structure	process	outcome
accessibility	equity	availability of different organisations and services	affordability availability	equity health status user evaluation
effectiveness	equity efficiency cost		effectiveness of different parts of process	equity health status user evaluation cost

We thus may conclude that quality consists of many aspects, especially since the tables above only contain clusters of aspects. For example, in 'effectiveness of different parts of process', one can look at the effectiveness of transport by ambulance car, or the effectiveness of intubation by a doctor, but also at the effectiveness of communication between different care providers, which can be hard to determine.

All quality aspects mentioned in table 6.2 are in itself aggregations: availability as part of accessibility and process, is not one thing – it includes availability of care at all parts of the process (so among different organisations, in different parts of the country, etc), and at all levels of the human-tech ladder: availability of care has to do with the physical availability, but also with the cognitive processes in the minds of both the patients and the medical personnel. The team and organisational levels are also involved, for there the communication and scheduling must make sure that there is care available. Finally, the political level is involved, for instance, because the ministry provides funding (or not) to create or sustain availability.

The combination of the quality framework and the human-tech ladder can be seen below in figure 6.1. In this figure, table 6.2 has been transformed into a three-dimensional frame, in which the same table is lined up five times. These five layers correspond with the five levels of the human-tech ladder, as is shown in the figure. This relation means that, when working on innovations that should improve quality, all levels are important for reaching that improvement.

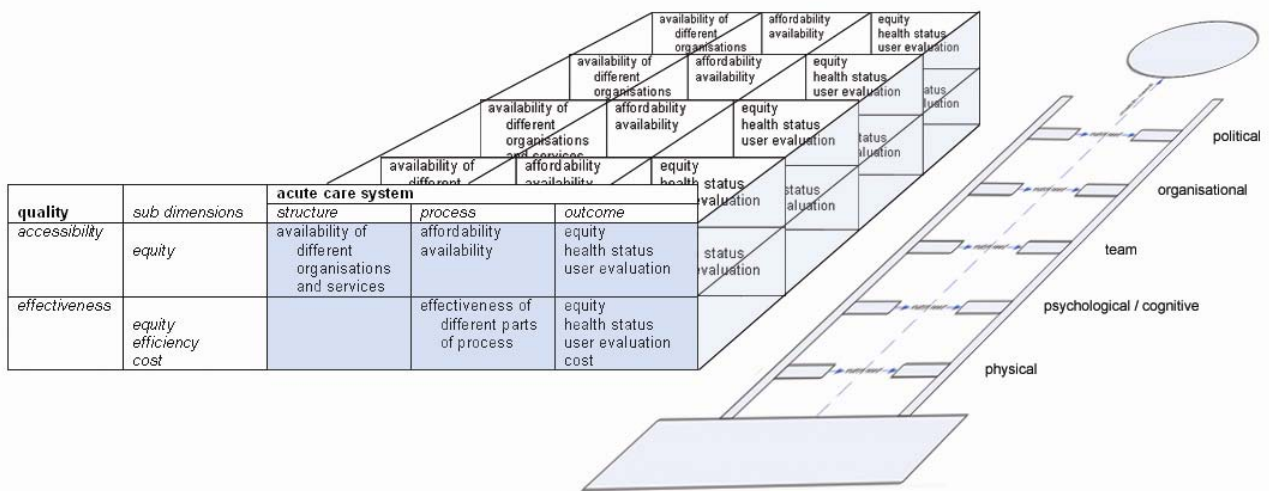


Figure 6.1: The quality framework and the human-tech ladder: every aspect of quality consists of all levels of the human-tech ladder.

## 6.4 Conclusion

Quality is multifaceted. This makes quality difficult to measure. The indicators that were developed by the RIVM only focus on the direct interaction with the patient, while a lot of other actions and circumstances influence the quality of care. A very important aspect of quality is that every part of quality is being influenced and determined by different levels of the human-tech ladder. Quality problems thus need to be tackled at different levels at the same time.

The quality framework as presented in table 6.2 in section 6.3 can be useful for pinpointing specific aspects of quality to design innovations for. Figure 6.1 offers the possibility of checking innovations by looking at both the quality aspects and levels. Does the innovation cover everything? Is it T-shaped, and does it have clear quality aspect goals?





## 7 Roadmap for innovation of the acute care system

In this chapter, all information gathered in the previous chapters on how to change the acute care system in such a way that it supports quality improving innovation, will be combined. In section 7.1, the most important and useful aspects of the human factor approach are listed. Section 7.2 recapitulates the requirements for an error reporting and analysis system, while section 7.3 covers the characteristics of an innovation supporting system. Of all these parts, a 'roadmap' for innovation is created in section 7.4. Section 7.5 treats the case that was first presented in section 2.11. Finally, section 7.6 draws conclusions about this chapter.

### 7.1 Incorporating the human factor approach in the acute care system

After its introduction in chapter 3, the human factor approach was used in every chapter to show coherence and connections between all levels of the human-tech ladder. In chapter 5, it has also shown to function as a guide, rather than only as a means of reflection or analysis. In chapter 6, the explicit link was made between different aspects of quality and the levels of the human-tech ladder.

This has created a point of view, a lens – so to say, that provides a rather complete and consistent look on the abstract problem of quality of acute care. It offers the possibility to conclude things about quality without ignoring the complexity of the system (as would happen by introducing aggregated scores, for instance). As such, this approach allows insight into quality (or the lack thereof) on a system level, just by going through the system and thinking analytically. The approach will not provide any numbers or aggregated performance scores, but that was never the goal: it is not about measuring quality to be able to assess what should improve, but it is about gaining insight in parts of the system that are a quality liability and knowing how to change those parts in an integral way. As such, this new approach will not replace the RIVM indicators, but will fulfil one of the goals they have (and fail to fulfil themselves): truly gaining insight into what is happening when things go wrong and finding out what to do about it in a thorough, systematic way.

### 7.2 Error reporting and analysis system requirements

The proposition of chapter 5 was: error analysis can help in finding flaws in the system in an efficient and effective way. Error analysis is indeed more efficient than analysing the whole acute care system without a certain starting point, but it is more work than just 'blaming the person'. Especially the cases described in chapter 5 have shown that error analysis is an effective way of finding flaws: in anaesthesiology and in aviation, they have benefited greatly from the lessons drawn upon reports of errors or near misses.

Using the human-tech ladder as a guide, the analysis of errors can lead to insights and recommendations on a system level.

#### ***Problems with error reporting in the acute care system***

There is a problem though, a roadblock on the way: the superhuman culture present in the acute care system makes it difficult – if not impossible – for medical practitioners to admit they make mistakes. Changing a culture is very difficult and takes years. Therefore, it is very important to show the benefits of the new system, through case studies from other fields, or through pilot projects. Changes in education can also have a large impact on the superhuman culture.

Another roadblock is the fragmentation of the acute care process: because of this fragmentation, it is difficult for medical practitioners to see their own errors, because they never get the complete story about a patient and thus do not get information about what the health outcome of the patient was.

#### ***Ingredients for an error reporting system***

Based on the aviation case study in section 5.6.3, the main 'ingredients' for an error safety reporting system are:

- confidentiality
- voluntary participation
- non-punitive system

- the processing organisation must be an independent organisation (not related to supervising bodies with reprimanding power)
- in depth analysis of reports by experts is necessary
- dissemination of findings in different ways and to a broad audience is necessary; to make the field progress, and to show that 'people are listening'

### 7.3 Innovation supporting system

Chapter 4 has shed light on many aspects of innovation. Two main findings are the enablers of innovation, and the fact that innovations mostly are T-shaped: they are spread over multiple levels of the human-tech ladder. The human-tech ladder should be central to the development of innovations, since this ensures a system approach for every innovation, which means insight into the true nature of the problem.

#### *Enablers of innovation*

Below the enablers of innovation are listed once more. These are characteristics of the system that can support and/or foster innovation:

- **innovative culture** must be **supported from the top**
- **reward innovative people** or teams in the system (not per definition financial, also recognizing and valuing their efforts helps)
- **resources for innovation**: inadequate resources are the biggest obstacle for innovation
- **diversity** of staff background: people with different backgrounds have different perceptions and ideas, which will help in creating innovative ideas
- **look outside** the system: learning from other organisations and systems
- **innovation is everyone's responsibility**: information and ideas from all levels of the system are important
- **experiments are essential** for innovation (Borins (2006) also mentions that this could be encouraged by reducing the costs of failure for the innovator)
- **evaluation is essential** for innovation

In other words, the acute care system could benefit greatly: if everyone (but especially the boards) wants innovation, wants to improve the care they provide together and feel responsible; if innovativeness is rewarded and supported; if there is money and time to work on innovations; if people with a non-medical background, for example, help in innovating the system; if there is room for experiments; and if experiments and innovations are evaluated thoroughly.

#### *Innovations are T-shaped*

Although an innovation always has an emphasis on a certain level of the human-tech ladder, it influences or interacts with other levels. This argues in favour of using the human factor approach when developing innovations.

### 7.4 The roadmap for innovation

Combining all of the above, the roadmap for innovation of the acute care system, with the ultimate goal of improving quality, looks like this:

- People need to be convinced that the human factor approach is useful and is appropriate for the acute care system
- The human factor approach needs to be adopted
- An error reporting system needs to be developed, using the human-tech ladder as a guide
- The error reporting system in combination with the human factor approach offer the possibility to create new innovations. These innovations are based on the findings from error analyses, and are developed into T-shaped innovations to increase their chances of success.

Below, this process is depicted in figure 7.1. The top row shows the adoption of the approach. The middle row depicts the development of an error reporting and analysis system – an innovation in itself. The bottom row shows the new tool: an error-based human factor approach. This tool uses error analysis as input and creates other innovations (at this point obviously unknown).

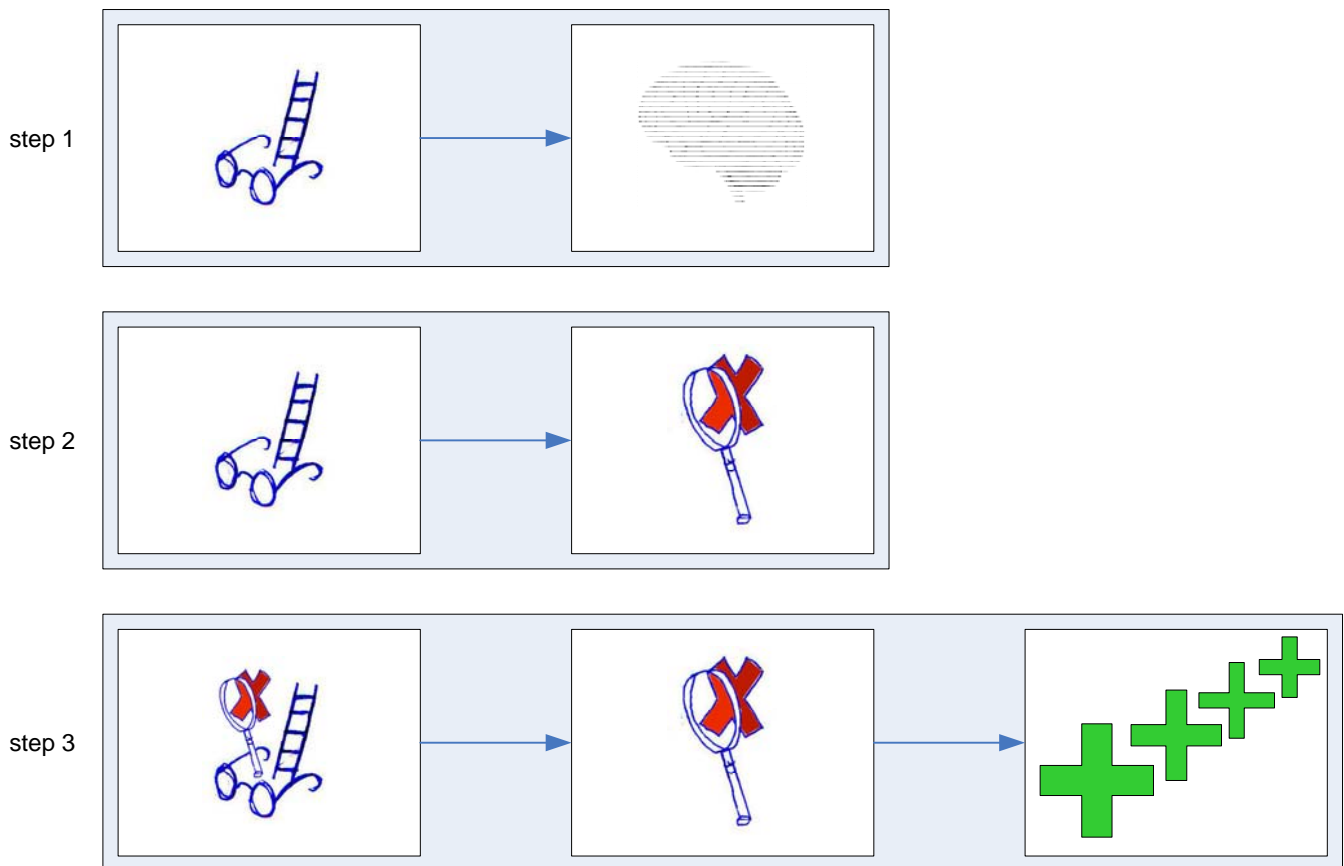


Figure 7.1: The roadmap for innovation. Showing the adoption of the human factor approach (step 1), the development of an error reporting and analysis system (step 2), and the use of that system to develop new innovations (step 3).

This roadmap is meant for the problem owner, the ministry of Health, and for the system as a whole. If they want to deal with quality issues on a systems level, they need to adopt the human factor approach, and the approach must be accepted by other actors in the system: this is necessary for the acceptance of innovations, but also because for successful innovations, a shared effort is needed. The development of an error reporting system will help in finding flaws in the system. The human-tech ladder can be used as a guide for developing the error reporting system. The flaws that are found can be removed by following the same procedure again: using the human-tech ladder.

Problems for implementation are: first of all, that the ministry has to be convinced that this approach will work. Besides that, the problems mentioned in section 7.2 can act as roadblocks for the progress on this roadmap.

### 7.5 Case: errors in acute care, using the roadmap

Currently, the only analysis of specific errors in acute care is conducted by the disciplinary council (and investigations of large accidents and disasters, but they fall outside the scope of this research). This has its limitations: due to their official field of work, and the norms they judge upon, it is only possible to judge a BIG-registered practitioner without being able to expand the analysis and judgement to the system. In this section, first the case from section 2.11 will be taken as an example to show the limitations of the disciplinary council. Then the case will be discussed in the light of the human factor approach: what would have been possible, if there was an opportunity to research errors in this case using the human factor approach?

#### ***The case: complaints with and judgements of the disciplinary council***

As was explained in section 2.11, six complaints were filed against the following practitioners that were involved in the death of the man with SAH:

- the registrar neurologist (06/252)

- the medical manager of the emergency department of the first hospital (06/253)
- the HAP doctor (06/254)
- the SEH nurse (06/255)
- the medical manager of the CPA (06/256)
- the (BIG-registered) person working at the HAP (who handled the phone calls) (06/257)

The verdicts for complaints numbered 06/253 and 06/256 were not published (and, as such, the complaints are not publicly available either). The last complaint, number 06-257, was pronounced non-admissible, because the person handling the phone calls was not BIG-registered – while this should have been the case – and thus the disciplinary council cannot judge upon it: only BIG-registered practitioners are subject to the disciplinary rules.

Against the registrar neurologist, four complaints were filed, of which one was judged to be non-admissible, and the other complaints were rejected. Seven complaints were filed against the HAP doctor, mostly concerning his late arrival at the home of the patient and his ‘mistakes’ in diagnosing the patient. Interestingly, the late arrival cannot be ascribed to the HAP doctor, because he did not hear about the patient earlier. In that case, the telephonist was erring, but that person cannot be judged by the disciplinary council, since s/he is not BIG-registered. The fact that a non-registered person handles the phone calls should be addressed to deal with quality problems on that point, but the disciplinary council is unable to do that. Almost all complaints were judged to be unfounded, apart from the fact that the HAP doctor ‘falsified’ his report the following morning: this should not have happened and thus has been judged founded, but the disciplinary council also concluded there has been no harm due to this action: therefore, no disciplinary measures are taken. The two complaints filed against the SEH nurse were judged non-admissible and unfounded, respectively.

Although some of the complaints did show possible flaws in the system, the disciplinary council was not able to deal with them, since it is not in their power to judge the system.

#### ***The case: using the human factor approach***

Since it was not possible to research this case using the human factor approach – more information from all people involved would be necessary – a fictitious view will be given in this sub section. From a human factor point of view, it is interesting and important to know more about the circumstances under which people had to work: it was late at night, so probably people were tired, perhaps it was a busy night, practitioners were dealing with personal problems as well: we cannot know what happened then. A couple of examples will be given below:

- The fact that both the patient and his partner did not recognise the severity of the headaches and the other symptoms, until the complaints had become very serious points towards a knowledge gap. It is hard to say whether people without a medical education should know about this kind of symptoms and how to act, but it might save lives to instruct people (by a campaign, like the campaign on strokes) that when they suffer from severe headaches combined with vomiting, they should visit a doctor right away.
- The HAP practitioner handling phone calls was not BIG-registered. This means that s/he was not entitled to triage patients. Why did s/he do that job? Are there scheduling problems? Is it easy (and cheaper) to employ people that are not qualified? Which organisation watches over this?
- Why did the CPA (of emergency phone number 112) demand that the patient first needed to be seen by a doctor, before an ambulance could be sent? Perhaps it was difficult to assess the illness of the patient over the phone, or the partner of the patient did not manage to convey the severity of the situation. Asking the right questions to assess the situation is difficult.

In this way, using the human factor approach it is possible to analyse actions and circumstances and to think of ways to prevent errors or change the way people deal with them.

## **7.6 Conclusions**

By combining different findings from this research, a roadmap has been created. It can be used as a guiding principle for the acute care system: it is a systemic way of mapping quality, which results in pointers for the type of innovations needed.

The case has shown the limitations of the disciplinary rules and council, and the opportunities of using the human factor approach have been explored.



## 8 Conclusions and recommendations

In this final chapter, conclusions will be drawn up, and recommendations will be made. In section 8.1, conclusions will be made by answering the sub questions as presented in section 1.3. Recommendations are made in section 8.2.

### 8.1 Conclusions

The acute care system is: "The chain of actions aimed at providing care as soon as possible, but in any case within a matter of minutes to a few hours, to prevent death or irreversible health damage as a consequence of an acute life-threatening disorder or an accident." (Raad voor de Volksgezondheid en Zorg, 2003)

The routes the patient might take through the system depend on the assessment of different people with different backgrounds (medical or not) and different circumstances (stress, fatigue): it is very well possible that because of this human factor, the routes are not efficient and may lead to (permanent) health damage or death. The system communication is not working properly: it lacks communication possibilities, which can result in an ambulance arriving at a full or unavailable hospital, because the hospital could not contact the ambulance. Besides that, there are capacity problems with the C2000 communication system.

The people working in the acute care system have heavy jobs: risks and stakes are high, and people always need to act fast and correct. The web of norms, guidelines, protocols, laws, and regulations is complex and determines the organisation of the acute care system. This automatically results in a complex system.

Since there are signs that the acute care system does not function optimal, and there is uncertainty about the quality of the system, it can be useful to aim for innovations that improve the quality of the system. "Successful innovation is the creation and implementation of new processes, products, services and methods of delivery which result in significant improvements in outcomes efficiency, effectiveness or quality." (Mulgan & Albury, 2003) As stated before, the goal of innovating should be to increase quality. More specific goals are improving health outcome for patients (increase effectiveness), and reducing costs of maintaining the system (efficiency and innovation: reaching and raising the optimal production curve).

The acute care system has a couple of obstacles in place that hamper innovation, such as inadequate resources and a short-term planning horizon. The most important requirement for an innovation-supporting system, is that it should adopt a systems view, and accept and support the human factor approach of innovation development that takes into account the different levels of the system. There are also other, but smaller, points that could help the system forward, such as removal of the obstacles to innovation, and introduction or enforcement of the enablers of innovation as described in section 4.3.

The human factor approach is used as a specification of the systems approach, because the presence of people in the system increases the level of complexity tremendously. The human factor approach is about expanding our knowledge of human capabilities and applying it to the design of technology. The goal of the human factor approach is to optimise the fit between technology and people on five levels: the physical, the psychological / cognitive, the team, the organisational, and the political level. The human factor approach can be used to gain insight into the system, because it shows the human factor requirements that should be met by a technology. If on all levels the human and technological ends meet, you get closer to the goal at the top of the human-tech ladder.

The human factor view on human error sees human error as a symptom of a problem deeper inside the system. Well-intentioned people are compromised in their pursuit of success, because of imperfect features of the system they have to work in (Dekker, 2006; Woods & Cook, 1999). Rather than concluding with blaming a person, one can learn from finding the system failure. Errors are made by everyone, not only by 'bad apples' and errors tend to recur: patterns can be found when looking at errors on a system level. Applying a system approach can prevent errors in the future.

Specific tensions in the acute care system concerning errors are about:

- superhuman culture in health care
- educational levels, functional independence, and scientific acting
- error awareness and feedback from the system

The differences between the fields of acute care, aviation, and anaesthesiology are large, but lessons can be learned. The anaesthesiology case showed an example of the critical incident technique. Cooper et al. (1978) only included incidents that were preventable: the fact that very often in health care, incidents are not preventable due to the high uncertainty, is important. The study by Cooper et al. (1978) was a success because it showed very clearly to other anaesthesiologists on what fields improvement was necessary, and as such provided them with a roadmap to safer anaesthesiology.

From the ASRS case, it becomes clear that the policy framework for a reporting system is complex. In the ASRS case, it took a long time before it worked, mainly because there were no positive incentives for aviation personnel to report. Main 'ingredients' for an error safety reporting system, based on ASRS are: confidentiality, voluntary participation, non-punitive system, processing organisation must be independent, analysis of reports by experts is necessary, and dissemination of findings in different ways is necessary. It is also important that the policies 'fit in' with already present laws, regulations, and other regulating bodies.

Quality of acute care is multifaceted. This makes quality difficult to measure. A very important aspect of quality is that every part of quality is being influenced and determined by different levels of the human-tech ladder. Quality problems thus need to be tackled with a systems approach: at different levels at the same time. The indicators designed by the RIVM for the IGZ are shallow in the sense that they only deal with the operational level and do not consider multiple aspects and levels of quality of care.

Currently, the only analysis of specific errors in acute care is conducted by the disciplinary council (and investigations of large accidents and disasters, but they fall outside the scope of this research). This has its limitations: due to their official field of work, and the norms they judge upon, it is only possible to judge a BIG-registered practitioner without being able to expand the analysis and judgement to the system.

The roadmap can be used as a guiding principle for the acute care system. These are the main aspects:

- People need to be convinced that the human factor approach is useful and is appropriate for the acute care system
- The human factor approach needs to be adopted
- An error reporting system needs to be developed, using the human-tech ladder as a guide
- The error reporting system in combination with the human factor approach offer the possibility to create new innovations. These innovations are based on the findings from error analysis, and are developed into T-shaped innovations to increase their chances of success.

This way human factor error analysis can help in supporting quality improving innovation in the acute care system.

The complete approach as presented here is meant to show how to look at the acute care system and its quality on a system level, and, consequently, it is about showing where the system has flaws. Really knowing 'where it hurts' in the system, will provide the opportunity not for a bandage, a quick fix, but for a full repair.

## 8.2 Recommendations

On the basis of this research, the main recommendation is to research in what way the human factor approach and the roadmap can be implemented. The roadmap presented is quite theoretical, and practical details still need to be designed. For example, there should be an independent organisation researching and analysing errors: which organisation should this be? Feedback from experts from the field is necessary.

First of all, there has to be a need / wish for looking on a system level. Besides that, people need to fully acknowledge that quality in acute care is an issue, and that there needs to be improvement of



that quality. If and when they are convinced of the need for a systems approach to deal with the quality issues, the roadmap as proposed in chapter 7, elaborated upon in a practical way, offers a way to deal with quality issues. To reach these first steps, it is recommended to bring people together to discuss quality issues and to explain the possibilities of changing the lens for a human factor lens.

There will also be flaws and/or difficulties in using the roadmap, though: it might be hard to use, to understand. Iterations and improvements of the roadmap will be necessary. In chapter 10, possible further research is discussed.

With this conceptual, theoretical study, I hope to have contributed to the insight into the acute care system and to the future quality of acute care. I am looking forward to getting feedback from the field.



## 9 Discussion and reflection

This chapter will discuss different aspects of this research and the problem field, and will reflect on this research.

### ***Problem in the acute care system: not only a quality issue, but also a decision making issue***

When looking through this report, the problem can seem to be a quality problem, but the approach taken – the systems approach – clearly shows that it is a policy and decision making issue. The roadmap is meant to facilitate decision making and policy making for the ministry of Health.

Following the roadmap should lead, if the roadmap itself is correct and used accordingly, to more insight into a number of problems in acute care. It also should facilitate the search for innovations that are dealing with all levels of the system. The main question that remains is thus: is the roadmap correct and useable?

Acute care quality will stay a complex issue, for most patients in the system are already very ill and very vulnerable: a large number of these patients die 'anyway' – no intervention can save those patients, but at the start it is not clear what the outcome will be, so all care needs to be provided to possibly save that patient. This also makes quality hard to measure, for the quality is in the process, not in the outcome.

In this research, the focus was not on measuring quality, but on dealing with quality issues. This seems a suitable way of dealing with the complexity of quality, for the main goal is to improve quality, not to measure it and to create aggregated scores.

### ***This research – would I have done it differently?***

This research has been one large conceptualisation, which cost a lot of time. The disadvantage of this is that there has been no room for experimentation and reflection: having some feedback on how people use the roadmap would increase insight into the quality and functionality of the roadmap as a tool. I would like to discuss this with policy makers in the field of acute care, in order to improve on the approach. For example, I can imagine that looking from a systems perspective is not easy for those who have never worked this way. Perhaps, from speaking with people that should apply it, it is possible to create a more elaborate roadmap that 'walks people through' or helps in another way.

### ***Personal reflection***

This has been my first own large research project. It was exciting and stressful at times, but I am very glad with the way I could use both of my engineering studies: Industrial Design Engineering, that 'supplied' the human factor approach, and Engineering and Policy Analysis, that formed the overall scope of this research. I feel my background truly has been of added value for this research and I hope I can pursue my career in the same way: using different schools of knowledge to create solutions.

The project itself provided me with the opportunity to give attention to the complex field of acute care. It is an inspiring field, since people working in this system are (almost) heroes: they work under tremendous time and location constraints, with very ill patients, and with large risks in general. This makes it difficult to judge these practitioners: they are doing great, important jobs. This research was therefore not meant to be critical of the people working in the system, but about supporting them to do a better job.



## 10 Further research

This chapter contains a couple of recommendations for further research. Follow-up research can have different scopes. First of all, one option is to look at the content of this research and try to validate, test, and elaborate the roadmap presented here. This means the roadmap should be tested, preferably in a real setting. This is difficult, because as explained in this research, a lot of high-level adjustments are necessary for a good implementation: for example, practitioners should be safe to tell about errors or near-misses without being afraid of persecutions.

Another research option is to wait until after (experimental, local) implementation, and research the effects of the roadmap and to see whether it really is supporting and fostering innovation.

Finally, another scope for a research similar to this one would be to look closely at the superhuman culture in health care, to find the causes of this culture, and to look at ways to change this culture, since cultural features are generally hard to change.



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## Appendices

List of appendices:

- Appendix A: List of interviews with findings
- Appendix B: Art.2 of Kwaliteitswet Zorginstellingen (Quality of Health Care Institutes Act)
- Appendix C: Indicators for the acute care system (Rijksinstituut voor Volksgezondheid en Milieu, 2009)
- Appendix D: List of questions to find obstacles for innovation (Borins, 2006)

### Appendix A: List of interviews with findings

Interviews were held with:

- Jelle Doosje, GGD: we mainly discussed the administrative system as shown in section 2.8.
- Xander in 't Veld, TU Delft: this interview was about human error and reporting systems in aviation. The results are used in chapter 5.
- E. van Ankum, IGZ, written interview: this written interview contained a couple of questions on the indicators used for measuring quality of acute care. Results are presented in sections 1.1 and 2.9.

Other personal communication was with:

- M.E.R. van der Klauw, innovation science: this conversation was about general theories of innovation. The outcomes were used to create chapter 4.

### Appendix B: Art.2 of Kwaliteitswet Zorginstellingen (Quality of Health Care Institutes Act)

*“De zorgaanbieder biedt verantwoorde zorg aan. Onder verantwoorde zorg wordt verstaan zorg van goed niveau, die in ieder geval doeltreffend, doelmatig en patiëntgericht wordt verleend en die afgestemd is op de reële behoefte van de patiënt.” (KWZ, art.2)*

*“The health care provider offers reliable care. Reliable care is understood to mean care of good quality, that is in any case, effective, efficient, and patient-oriented, and is geared to the actual needs of the patient.”*

### Appendix C: Indicators for the acute care system, cited from (Rijksinstituut voor Volksgezondheid en Milieu, 2009)

#### **Ziektespecifiek – beroerte**

1. Maken en beoordelen van CT-/MRI-scan binnen 3 uur na het ontstaan van symptomen
2. Toedienen van rt-PA binnen 3 uur na het ontstaan van symptomen
3. Tijdsduur tussen het maken van een CT-/MRI-scan en het toedienen van ASA
4. Tijdsduur tussen het ontstaan van symptomen en opname op een stroke-unit

#### **Ziektespecifiek – acuut myocardinfarct**

5. Reperfusie binnen 12 uur na het ontstaan van symptomen
6. Trombolysie binnen 60 minuten na inroepen van professionele hulp
7. PCI binnen 90 minuten na inroepen van professionele hulp
8. Maken van ECG binnen 20 minuten na inroepen van professionele hulp
9. Tijdsduur tussen het maken en het beoordelen van een ECG
10. Toediening van ASA binnen 2 uur na eerste contact met zorgverlener
11. Tijdsduur tussen 112-melding MKA en defibrillatie

#### **Ziektespecifiek – combinatie beroerte en AMI**

12. Transport met A1-rit en vooraankondiging bij beroerte en AMI

### **Ziektespecifiek – ernstig trauma**

13. Tijdsduur tussen 112-melding MKA en vertrek ambulance 2 minuten of minder
14. Tijdsduur tussen 112-melding MKA en vertrek MMT 2 minuten of minder
15. Tijdsduur tussen 112-melding MKA en aankomst van ambulance op ongevallocatie 10 minuten of minder
16. Tijdsduur tussen 112-melding MKA en aankomst van MMT op ongevallocatie 15 minuten of minder
17. Tijdsduur tussen aankomst bij de SEH en verlaten van de SEH 30 minuten of minder
18. Uitsturen van ambulance en MMT
19. Vervoer naar een level 1-ziekenhuis met traumafaciliteiten
20. Verbetering in AB-functies tussen eerste onderzoek op ongevallocatie en op de traumakamer/SEH
21. Maken van de volledige traumaserie röntgenfoto's (of CT-/MRI-scans)

### **Algemeen**

22. Tijdsduur tussen 112-melding MKA en aankomst van ambulance ter plaatse bij A1-rit
23. Capaciteitsprobleem ziekenhuis voor acute ambulancepatiënten
24. Verblijfsduur op de SEH korter dan 4 uur
25. Sterfte binnen 24 uur na binnenkomst op de SEH
26. Overdracht van informatie over prehospitala pijnmeting en pijnbestrijding bij aankomst op de SEH

### **Appendix D: List of questions to find obstacles for innovation, cited from (Borins, 2006)**

"Identifying these obstacles in detail enables us to formulate a list of questions for innovators to ask when designing an implementation strategy.

- How much will this program cost? Can the money be found through public sector appropriations? Will user fees be possible? Are private sector donations a possible funding source?
- Will the program require any changes in current regulations or laws? If so, what is the process involved and whose support will be required?
- Which organisations will be involved in delivering the program? If multiple organisations will be involved, what are their ongoing relationships? Are they organisations that rarely deal with one another, or do they have a history of rivalry, for example, turf battles? Will they fight for control of the program or fight to avoid involvement?
- What are the occupational groups that will be involved in delivering the program? How do they define their roles? What are the status relationships among the different occupations (e.g., professionals versus paraprofessionals)? Will cooperation of different organisational groups depend on understanding one another and/or on being able to do some aspects of each other's work?
- If the innovation involves the application of a new technology, will it encounter incompatible legacy systems being used by different organisational participants? Will the technology lead to job losses, especially in unionised positions? Will users of the new technology require special training?
- Who will be the key participants in delivering the innovation? Will they be expected to go beyond what is normally expected of them in their current positions? If so, how will they be motivated?
- Innovations sometimes require help from volunteers, especially if funding is limited. If volunteers are to be used, how will they be motivated to participate and how will their efforts be rewarded?
- Will the innovation create logistical problems, for example, scheduling conflicts among different participants?
- Will public sector unions oppose the innovation because it threatens job losses or affects the working conditions of union members?
- Will middle managers oppose the innovation because it devolves responsibility to frontline staff and weakens their supervisory authority?
- Will the innovation be opposed by central agencies, for example, because it reduces their control over financial or human resource decisions?

- Will the innovation face political opposition because it is inconsistent with some politicians' values? Will it face political opposition because it will reduce their ability to allocate resources to their constituents?
- Will there be difficulties in reaching the innovation's target group — for example, because they do not use the official language, because they have special needs, or because they are unreceptive to those normally mandated to deliver the service?
- Will there be public doubt or scepticism about whether the program can work?
- Will there be public opposition to the program, for example, an application of information technology that is considered by some to be an invasion of their privacy?
- Will the program face opposition from the public because it allows public servants to operate in ways or receive compensation (for example, performance-related pay) considered to be more appropriate to the private sector than the public sector?
- Will the program face opposition from private sector firms because it regulates their activities in ways that reduce their profitability or forces them to abandon a line of business?
- Will the program face opposition from private sector firms because it introduces public sector based competition?

This list of questions — formidable as it might seem — is not intended to dissuade potential public management innovators, but is designed to alert them to the challenges faced by those who have preceded them on the road to change. While all of these questions are worth asking, only certain obstacles may be encountered in a given case.”