# P4 Reflection

When I started the research, I didn't have much knowledge about fire safety and the effects of a fire safety approach for the design of buildings. The first step was to gain understanding of the subject. This was done by searching literature on fire safety and searching for information about (newer designed), and the effect of the current regulations as stated in the Dutch Building Decree for designs of hospitals. In this phase the question arises more and more if it is possible to find a more integrated approach that matches the real fire safety problems that are currently present in hospitals.

## Approach

One of the objectives of the research was to categorise data from egress times for different types of patients. After literature research I wasn't able to find existing data about the egress times of different types of patients. Experiments in real hospitals were required.

By recording an evacuation drill of an entire ward in an older hospital a lot of knowledge and data about the behaviour of staff could be gathered. The most important observation was that the level of trained staff is very important for the required egress time of a ward. The recordings also showed that when there was only one exit on a hospital ward that can be used for evacuation of beds, the required egress time increases a lot. If the bedridden patients need to be evacuated by using a movement device for evacuation on stairs, a successful evacuation seems to be unreachable. The recorded evacuation drill showed that when staff is not trained, the times found in already researched data are impossible to accomplish. The evacuation drills showed that if there is a fire in the corridor area, a successful evacuation is in danger and likely to be impossible.

The evacuation drills performed in the second hospital are more focused on purely getting data of egress times of specific hospital wards. The experiments where stricter to one evacuation route, or evacuating one patient multiple times out of the same patient room. For this reason the experiments could be better used to define average data for the different parts of the evacuation process.

Another objective of the research is to develop a design tool that can help designers to design safer hospitals. Using the probability approach in combination with a verified egress time of the entire ward, a calculated effect can be determined. Different options for the design can be implemented in the probability calculation, and will therefore influence the value that marks the level of fire safety of the layout. The options for designers will be much wider, and more options will be available, that can improve the awareness of fire safety, and makes the hospitals sufficiently safer.

## Research & Design

The aim of the research is to be able to create design guidelines for state of the art fire safety concepts for hospitals. The design trends, actual use and corresponding egress time need to be integrated in the guidelines. With the gathered data an RSET per specific hospital ward can be determined and calculated. With this determined RSET the actual use of a ward can be analysed. The amount of staff present is important for the RSET, and can be customised to get a smaller relative probability of casualties.

By creating a basic value for the probability of casualties of a layout that fulfils the current Dutch Building Decree regulations, wards with an entirely different layout can be compared on the level of fire safety. Therefore new design trends can be designed which are not only focussing on complying with the regulations which are focussed on maximum allowable square metres. New designs can follow the probability approach to determine a value that can be significantly safer.

This approach can also help existing hospitals with less efficient layouts for fire safety, to secure a certain percentage of safety for bedridden patients. Adjustments to the building can be made, to have a lower relative probability of casualties. But when investing in a building isn't an option, making sure a better level of trained staff is achieved, can help decreasing the chance of a developed fire. It can also help to make improvements to decrease the RSET, with better planning of extra staff arriving when an emergency occurs, or better trained so an evacuation can be executed faster. With this approach hospitals, can choose for example to improve in the organisation to decrease the RSET. With these improvements, the building can be sustained on an acceptable risk, instead of renovating or building a new hospital. The approach of the design tool gives options to make both new build and older hospitals tool to achieve an acceptable risk regarding the fire safety.

Improvements to the design tool could be made to link the chance of an occurring fire, more to the required egress time. In the scope of my research I was not able to link both these factors, to create one value per design. More research into data about fires in hospitals and egress times in different scenarios will be necessary.

With the graduation process coming to an end, I can say I gained a lot of knowledge about the fire safety approach in buildings with a complex design and comprehensive organisation. By thinking of designs for hospital wards on a different approach, it gave me knowledge how to implement the technology of fire strategies in the design process. By doing this research my interest in the fire safety engineering growth, and I would like to learn more about the topic in my further career.

# Answering the research questions

## Problem

### What are the current regulations in the Netherlands regarding the fire safety of hospitals?

The current regulations in the Netherlands are defined in the Dutch Building Decree. The most important regulations for hospital buildings are described in chapter 4.

### What are the differences in regulations between the Netherlands and countries with similar healthcare systems?

In chapter 4 a comparison is made between the regulations in the Netherlands and countries with similar healthcare system. Almost all regulations, are the same as the Dutch regulations, based on restrictions for the maximum allowable square meters in a fire compartment. The regulations do not focus on the actual required evacuation time.

### What are the current design trends for hospitals?

The design tendency of modern hospitals is shifting towards single patient rooms with a wider corridor with multiple functions. This design trend is following the principle of the healing environment which is more focussed on how architectural applications can contribute to the healing process of vulnerable patients. The design trends and healing environment are further described in chapter 5.

### What design trends have a direct effect on the fire safety?

With the current design trends for hospitals, with more single patient rooms in combination with a wider corridor, the fire safety risks are changing. A new strategy is required, as the strategy currently described in the Dutch Building Decree and other regulations. Also other design strategies for both existing and older hospitals have influence on the fire safety. For example in hospitals it is common that there are stairs at the end of the hallway. These important observations are described in chapter 5.
The effect of the changing design trends, on the actual risk and the RSET of a ward is displayed in chapter 9.

### What are the causes of actual fires in hospitals and what was the impact and damage?

As described in chapter 1 fires in health care premises are frequently occurring in the Netherlands, with a wide range of different causes. It is difficult to interpret these data directly in designing, because data is logged for all health care premises and I it is not possible to examine this date for hospitals because of the privacy policy. With more specified data about the actual causes, better strategies could be applied to prevent fires in hospitals.

### What evacuation choices have been made during actual fires in hospitals?

In chapter 3 are some actual fires described and discussed. These fires happened in hospitals or other health care premises, and are researched on why the fire could happen and could cause a serious threat. But also which problems occurred during evacuation. Analysis of these fires showed, hence buildings fulfil the restrictions towards fire safety, there is no guarantee that a safe evacuation could be achieved.

## Research

### What are the categories and types of wards in existing hospitals?

During literature research egress data about different types of vulnerable patients was found. But data about the evacuation of patients on specific hospital wards was missing. Experiments are performed to extend the data available for different types of patients. With these extra data more specified egress calculations for different parts of hospitals can be made.

### Can a spectrum of vulnerability of patients in a hospital be defined?

It is difficult to predict the level of vulnerability of patients on a ward. Patient population is changing every day, so it is impossible for a design to make a diversity in vulnerability of patients. The evacuation calculations made in chapter 9 have as starting point that every patient must be evacuated in bed, with corresponding uncouple times per patient for that specific ward. In designs it is important that there is enough holding capacity for all patients in adjacent areas.

### What are the different types of equipment that a patient is connected to?

There is no specific research performed into the different types of equipment in hospitals. But during the experiments performed on the specific wards, patients were connected to the equipment which was regular for these wards. The equipment that was connected, was discussed with staff working on these wards, and described in chapter 7.

### What are the egress times of different groups of patients, including unplugging and unlocking of equipment?

Literature research confirmed that egress data about different types of patients were missing. During the research experiments are performed on different specific hospital wards. The experiments and the results are placed in chapter 7. The experiments showed that there is a big difference in evacuation time per patient in different types of wards.

### Do physical conditions (for example obesity) of a patient affect egress times?

After discussing with staff of hospitals about the possible effect of patients with obesity on the total evacuation time of a ward, it is mentioned that patients up to 200 kg are still in regular beds, and patients in special beds do not occur often. The effect on the evacuation speed will be nihil, when patients are still in regular beds and can be evacuated in bed. The effect of obesity is therefore not further investigated.

## Design

### What egress times can be defined and categorised after research and experiments?

The first part of the research was focused on finding existing data. Experiments are performed to extend available data about evacuation times of patients on specific wards. With these data more integrated strategies can be created, to design significantly safer hospitals. Research and performed experiments are described in chapter 6 and 7. An overview of egress data is added to the appendices.

### What department of staff members are necessary in leading/organising the operation of evacuating a hospital? (especially during night times or weekends)

Experiments when an entire ward had to be evacuated during an evacuation drill showed that delay of the evacuation will occur when staff needs to discuss in which order patients have to be evacuated. It seems important that staff exactly knows how to handle, and that every staff member can contribute to a faster evacuation. Staff needs to be trained frequently, but evacuation procedures should keep simple, to avoid mistakes made by staff. The results of experiments are discussed in chapter 7.

### What are the consequences of these egress times for the design?

With the gathered data about evacuation times per patient, it seems necessary to chance the fire safety strategy for hospital wards. Fire safety strategy should be more focussed on the actual risks, and the required egress time. By taking different parameters into account, when a design is made or renovated, a more integrated fire safety strategy can be developed. Examples of a more integrated approach for designs are described in chapter 8 and 9.

### Are there architectural precedents that demonstrate safe and efficient evacuation of hospitals? (partly based on analysis of existing hospitals)

With the probability approach combined with accurate RSET calculations, designs for existing and new hospital wards can be analysed. It is possible to improve or adjust the layouts with different parameters, combining staff, architectural adjustments and fire protection systems. The different options for designs are displayed in chapter 9. The analysis of the layouts of existing hospitals is added to the appendices.

### What visual design proposals can be derived for a fire safety concept that contributes to safer use of hospitals?

The aim of the research was to create flexible guidelines that can help designers making hospital designs with a more integrated fire safety strategy. With the different parameters applied, multiple variants for new designs are possible. The approach is described in chapter 8 and some examples are elaborated in chapter 9.

## Main research question

*What design guidelines can be derived for a fire safety concept in hospitals that matches new design trends, actual use and corresponding egress times of vulnerable patients?*

With the design tool an interactive approach is created, to be able to design layouts for hospitals which consider multiple parameters. Layouts can be designed with fewer restrictions, but consider actual use, presence of trained staff and validated specific egress times for different types of patients.