

INNOSOC Case Study

(selected for Valencia 2017; extended version)

Case Study title:

High-Reliability Healthcare Systems

Keywords: reliability; healthcare; complex systems; uncertainty

H2020 challenge addressed by the Case Study: Health, Demographic Change and Wellbeing

Introduction to the Case Study

Reliability analysis plays a key role in development of high-reliability healthcare systems. The first works dealing with the analysis of such systems were published in 1960s and 1970s. These works assumed that only **medical equipment and devices are important** from reliability point of view. This further implied that reliability of healthcare systems could be increased just by increasing reliability of medical devices.

Nowadays, medical devices are perfectly functioning systems with minimum faults, but **healthcare systems are not high-reliable** and, according to information presented in [1][2], a medical error [3] is one of the leading causes of death in the US. In case of the EU, it is estimated that **8-12% of patients** admitted to hospital suffer from **adverse events** whilst receiving healthcare [4]. One of the main reasons is that a healthcare system is composed not only of medical devices [5] but also of medical staff [1][6]. The staff as a part of a healthcare system can be examined using methods of **human reliability analysis**. This approach is used in the analysis of healthcare systems from 1960s but **it has not resulted in high-reliability healthcare**. A reason for this can be a fact that human errors for a healthcare system have been considered independently of medical devices. However, they are not independent problems. For example, a medical error can be caused by incorrect functioning of a medical device that can result from human medical error. In [7], a **new approach for reliability analysis of healthcare systems** has been considered: the reliability analysis has to be based on joint evaluation of all principal parts (components) of healthcare system, i.e. medical devices and medical staff.

INNOSOC students, supervised by INNOSOC lecturers, will collaborate on answering how this approach can be further developed and used in transforming healthcare systems into highly reliable systems accessible for everyone. These activities will be conducted as a part of the ERASMUS+ blended mobility and will be finalized during the INNOSOC Valencia 2017 workshop in late May 2017.

How this Case Study is related to the selected H2020 challenge?

The Horizon 2020 challenge dealing with Health and other aspect of Wellbeing aims to improve quality of healthcare and develop better health for all. One of the possible solutions to these goals is development of approaches that result in increase of reliability of healthcare systems in such a way that they will become highly reliable systems.

One of the main benefits of high-reliability healthcare systems is **improvement of health monitoring** and **treating and managing disease**. However, the main problem behind development of such systems is their complexity. Healthcare systems are composed of many elements differing in their nature. Because of that, creation of a mathematical model that takes into account all relevant factors is not a straightforward task and requires a lot of effort and testing.

A good mathematical model allows us to investigate reliability and propose approaches that can be used to increase reliability of the healthcare system with high confidence. Results of such analysis can be very useful in development of new more reliable **models of healthcare**. Testing of these new models can **improve our understanding of the causes and mechanisms underlying health** and their realization/deployment can **deliver perfect healthcare** to everyone.

How this Case Study is related to the INNOSOC project?

In the frame of the Case Study, the approach for investigation of reliability of complex systems proposed in [7] will be tested using examples of healthcare systems from [1][5]. The approach is based on modern methods of reliability analysis, such as logical differential calculus, and data mining, such fuzzy decision trees. One of the main questions is how to extend this approach in such a way that it allows taking into account uncertainties occurring in the investigated system [8]. The testing performed in the frame of the Case Study should help to solve this problem, and the obtained results should be used in its further improvement. Successful completion of this and other issues can result in a complex **innovative** approach that allows designing high-reliability healthcare systems delivering **perfect healthcare to anyone**.

High-reliability healthcare represents one of the key aspects of wellbeing. However, “wellbeing” is a very subjective term influenced by **culture** and **environment**. Students participating in the case study will present their views on wellbeing. Their ideas and attitudes will be very useful in further development of more general approach that allows improve reliability of healthcare systems considering also **cultural** and **social background** [9].

Healthcare systems represent complex systems composed of many non-homogeneous elements whose behaviour contains some kind of uncertainty. Typically, a healthcare system is composed of four types of components that can be identified as hardware, software, human factor and organizational element [7]. Because of that, models of healthcare systems are very complicated, and their analysis can be done only using fast algorithms running on computer. This implies that **ICT resources** play a key role in the analysis and improvement of healthcare systems.

Questions that need answers during the Case Study development

Questions that should be answered include but are not limited to the following:

- What is a system from reliability point of view? What is a complex system?
- What are impacts of medical error?
- How is a high-reliability organization defined?
- Which methods are used in human reliability analysis? What are their specifics?
- What are specifics of human reliability analysis in medicine?
- How can structure of a healthcare system be defined from reliability point of view?
- What are specifics of data from healthcare systems?
- How can the data for reliability analysis of healthcare systems be collected?
- Which methods can be used for reliability analysis of healthcare?
- How can healthcare reliability be improved?

References

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Knowledge and skills needed for developing the Case Study

(P: prerequisite; D: desirable, but not necessary)

- Probability theory (P)
- Basics of reliability analysis (D)
- Basics of fuzzy logic (D)
- Data mining (especially decision trees) (P)
- To have interest in Internet research (D)

- To be interested in improvement of healthcare (D)

Figures describing this Case Study

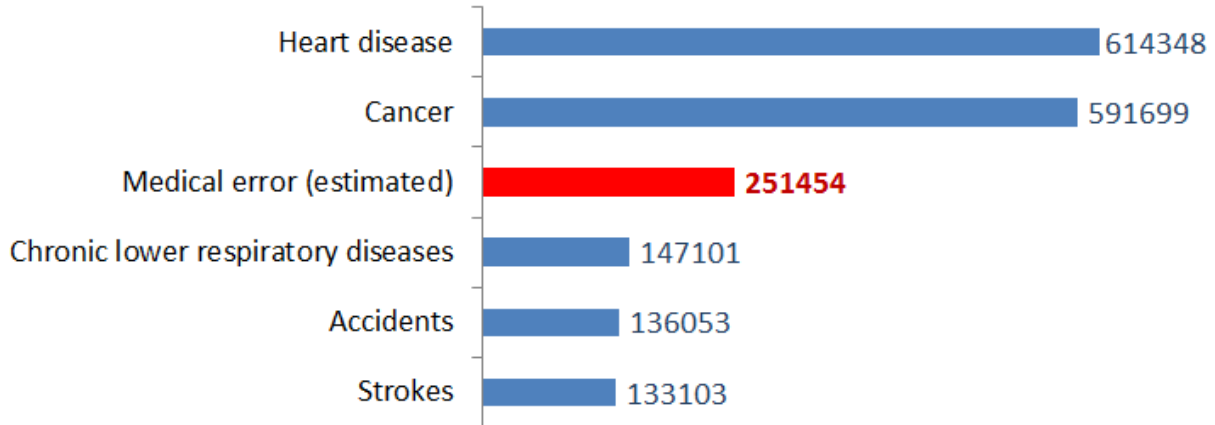


Figure 1. Medical error as the third leading cause of death (according to [3])

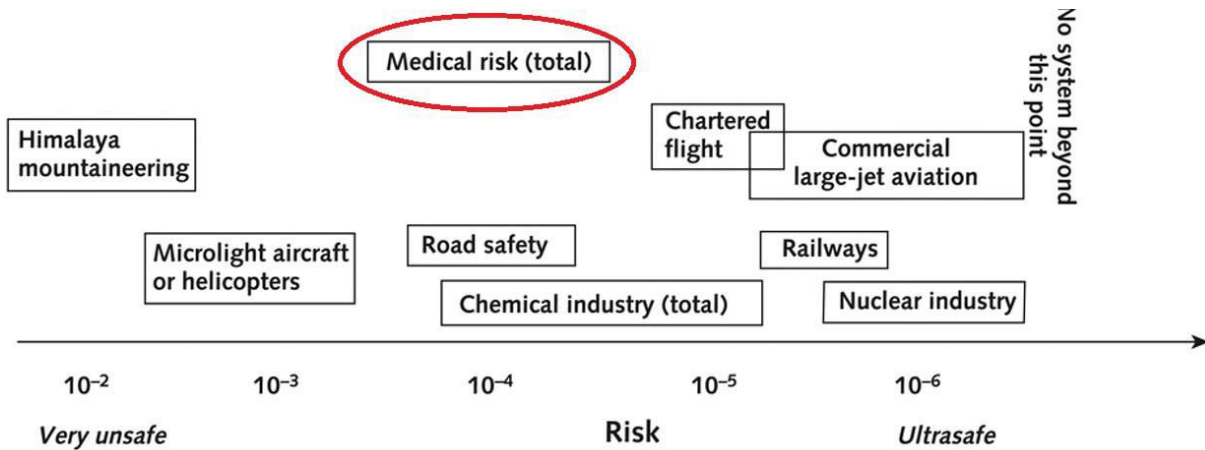


Figure 2. Medical systems as an unsafe system (according to [10])





Figure 3. Surgery as a complex system and its model for reliability analysis





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