

Use of Information and Communication Technologies for Increasing Resilience of Medical Facilities

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Abstract

The paper presents an applied research and development project, Monitoring and tracing the movement and contacts of persons in medical facilities, financed by the Research and Development Support Agency of the Slovak Republic and currently carried out at the Faculty of Security Engineering of the University of Zilina in cooperation with companies from practice. The main contribution of the mentioned project lies in the development and design of a system for the identification and search of contacts of persons based on the monitoring of their movement in the object of the medical facility through the selected information technology. The system can also be implemented in other premises with a large number of people. The paper also deals with the issue of the resilience of medical facilities from the point of view of their inclusion among critical entities providing basic services that play an irreplaceable role in maintaining vital societal functions. It points to the necessity of using information and communication technology in the health sector.

Keywords: ICT, healthcare, resilience, research

1 Introduction

In terms of its functioning, today's modern society is dependent on the functioning of infrastructure systems. Infrastructure that is vital for ensuring the functioning of the state and whose disruption or destruction would have serious adverse consequences for the implementation of the economic and social function of the state, and thus for the quality of life of the inhabitants in terms of the protection of their lives, health, safety, property, as well as the environment is referred to as critical infrastructure (hereafter CI). The key role of the CI is the reliable provision of services necessary to maintain the most important social and economic activities. Entities providing basic services in the internal market must be resilient to incidents, as these can cause serious disruptions not only within a specific industry but also cross-industry, possibly even with an impact on international systems (EC, 2022a).

Healthcare, which is a part of the critical infrastructure in the Slovak Republic, is one of the most important systems, the malfunction of which causes a serious impact on the health and life of the inhabitants, and subsequently also great economic impacts. The obligation of the state and operators of critical infrastructure to ensure an increase in the resilience of critical entities and their ability to provide their services in a defined area also follows from the Directive 2022/2557 of the European Parliament and the EU Council of 14 December 2022 on the resilience of critical entities (EC, 2022a).

Healthcare of the Slovak Republic forms an important subsystem of the state's security system because every crisis situation carries the potential for damage to health and loss of human life, as well as the need for rescue in

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the form of immediate and institutional health care. The importance of this sector was also confirmed by the Covid-19 pandemic which in a dramatically short time changed the life and way of thinking of almost all of humanity. It showed the fact how important the provision of quality healthcare, the functioning of medical laboratories, research and development of medicines, available medical aids and a number of other activities connected with ensuring the functioning of the healthcare sector are for society. The healthcare sector, like other CI sectors, must increase its resilience in order to effectively protect the population and prepare to deal with current and anticipated future threats and the risks arising from them.

The application of information and communication technologies in healthcare services has the potential to contribute to increasing the quality, cost-effectiveness, time availability and mobility of healthcare services but also to increasing resilience which represents the system's ability to ensure and maintain its functions in the face of negative internal and/or external influences factors.

The main goal of the paper is to present and characterize the originality and innovativeness of the project Monitoring and tracing the movement and contacts of persons in medical facilities, solved at the Faculty of Security Engineering of the University of Zilina. The paper also focuses on the topic of the resilience of critical infrastructure entities in the healthcare sector and points to the importance of applying information technologies that help reduce costs and administrative complexity, increase the efficiency and quality of healthcare, and also contribute to increasing the resilience of healthcare facilities.

2 Resilience of critical infrastructure entities

The European Union has been systematically dealing with the issue of CI since 2004. As part of CI protection processes, several documents were drawn up, mainly focused on prevention, preparedness and response to threats negatively affecting CI, especially with a focus on the threat of terrorism. Among the important outputs of this process is Council Directive 2008/114/EC of December 8, 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection.

However, in recent years, there have been significant changes in the operating environment of CI entities, and the risk of disrupting the provision of basic services is constantly increasing. For this reason, it has become necessary to fundamentally change the current approach to CI protection introduced in 2008 and move from the protection of specific infrastructures to increasing the resilience of critical entities that operate them. A revised approach to CI resilience that better reflects the current and expected future risk environment, the increasingly close interdependence of various industries, as well as the increasingly interdependent relationships between physical and digital infrastructures is simultaneously a priority of the EC and the EU Strategy for the Security Union. Based on the aforementioned facts, the European Parliament and the Council of the EU adopted the new Directive 2022/2557 of 14 December 2022 on the resilience of critical entities which repealed the 2008 directive.

The above-mentioned Directive imposes obligations on member states and operators of CI which relate mainly to the obligation to (EC, 2022a):

- identify critical subjects for the sectors and sub-sectors listed in the Annex of the Directive,
- ensure an increase in the resilience of these entities as well as their ability to provide their services in the internal market.

The identification of critical entities must be carried out by July 17, 2026. In order for such "critical entities" to be able to ensure their resilience, they must have comprehensive knowledge of all relevant risks to which they are exposed and have a system to analyse and manage such risks. For this purpose, they must carry out a risk assessment whenever necessary but at least every four years. Member States' risk assessments take into account all relevant natural and man-made risks, including risks of a cross-sectoral or cross-border nature, accidents, natural disasters, threats to public health and hybrid threats or other antagonistic threats, including terrorist offenses (EC, 2022a). Based on the risk assessment, critical entities must take relevant technical, security and organizational measures to ensure the required level of their resilience.

The topic of resilience of critical infrastructure is relatively new and interest in the issue has increased primarily due to the increasing dependence of society on the services of the most important – critical – infrastructure and also in terms of the occurrence of various disasters. In the literature regarding resilience, there are several definitions without a widely accepted definition (Klein et al., 2003), which are formed mainly by the field of application and the way of understanding (e.g. physical, infrastructural, economic, social resilience).

Resilience describes the ability of society, communities, individuals, or a socio-ecological system or a technical system to manage the adverse consequences and impacts of crisis situations (Birkmann, 2013). It is also understood as the ability of a system, community or society potentially exposed to danger to adapt, resist, or change, in order to achieve and maintain an acceptable level of its functioning and structure (IRIN, 2005).

In the field of social-ecological systems research, resilience is defined as the system's ability to absorb disturbances (deviations) and reorganize into a fully functional system. It includes not only the ability of the system

to return to the state that existed before the disturbance but also to improve its state by learning and adapting to change (Cutter et al., 2008).

Common elements of the definitions are mainly:

- the ability to withstand disruption while the basic functions of the system are not threatened,
- the ability to adapt to changes due to the action of negative factors,
- the ability to recover to the original state or better than the initial state.

3 Subjects of critical infrastructure in the healthcare sector

Directive EU 2022/2557 includes the institutions shown in Figure 1 as critical entities in the healthcare sector:

- Healthcare providers - any natural or legal person, or any other entity that legally provides health care in the territory of a member state (EC, 2011)
- The EU reference laboratories are responsible for coordinating the network of national reference laboratories in the fields (EC, 2022b):
 - a) reference diagnostics, including test protocols,
 - b) sources of reference materials,
 - c) external quality assessments,
 - d) scientific advice and technical assistance,
 - e) cooperation and research,
 - f) monitoring, issuing warnings and support in response to disease outbreaks, including in relation to new communicable diseases and pathogenic bacteria and viruses, and
 - g) training.
- Entities carrying out activities in the research and development of medicinal products, as defined in Article 1 point 2 of Directive 2001/83/EC of the European Parliament and of the Council (EC, 2001).

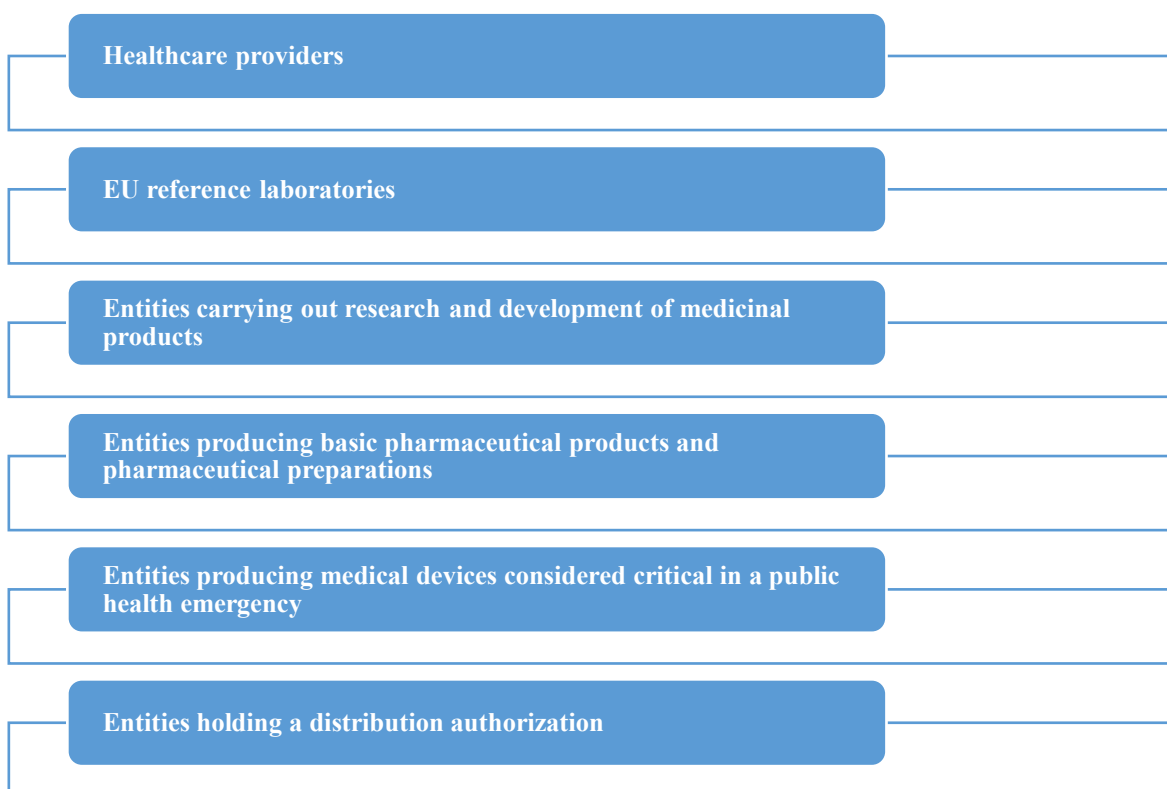


Fig. 1. Critical entities in the healthcare sector (Source: EC, 2022a)

- Entities producing basic pharmaceutical products and pharmaceutical preparations listed in Section C Division 21 NACE Rev. 2.

- Entities producing medical devices considered critical in a public health emergency within the meaning of Article 22 of Regulation (EU) 2022/123 of the European Parliament and of the Council (Regulation EC, 2022c).
- Entities holding a distribution authorization pursuant to Article 79 of Directive 2001/83/EC (EC, 2001).

4 Use of information and communication technology in the healthcare sector

Information and communication technology (ICT) is now a common part of everyday life. Health information technology includes services and tools that assist healthcare professionals in performing their daily activities. In other words, health information technologies today encompass various aspects, including data sharing, patient information management, medical imaging, patient education, disease management, clinical practice management, health record management, clinical decision support, and many others (ProHealth, 2022). The application of ICT in healthcare services has great potential in several forms (Ozorovsky et al., 2016) see Figure 2.

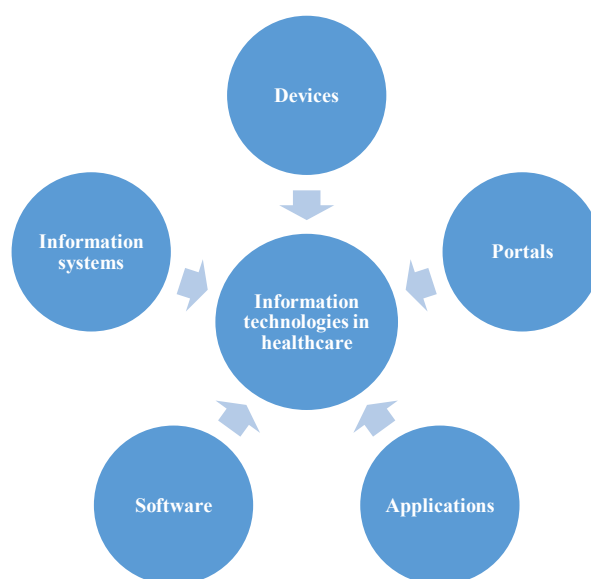


Fig. 2. Information technologies in healthcare (Ozorovsky et al, 2016)

- Devices - a large number of different types of devices are used in the healthcare industry which can be divided according to various criteria, e.g. imaging/monitoring devices (RTG, CT, USG, MRI, nuclear medicine, thermography, etc.), devices used for therapy, simulators. The current trend is smart devices which make it possible to expand basic activities by installing additional software.
- Portals - doctors, health workers, patients, and citizens increasingly need relevant information in electronic form. The source of such data is national health portals where all information is provided by experts. National health portals become part of the health system in a given country. Their priority is to provide information to citizens and healthcare workers that is up-to-date, complete, and professionally verified (Demcisakova, Sarmirova, 2016).
- Applications - currently they are connected with smart devices for which applications can be downloaded from the so-called application stores and then installed. Currently, a large number of different applications are used in the field of healthcare, such as moje ezdravie, iDoctus, DosisPedia, Medscape, eAlerts, 155.sk, and others. One example of the use of a mobile application to save lives is the PMcardio application which was developed by the Slovak company Powerful Medical. PMcardio helps medical personnel with the diagnosis and treatment of cardiovascular diseases. Thanks to artificial intelligence that uses knowledge from a million ECG recordings, PMcardio is as reliable as an experienced cardiologist with 30 years of experience. Clinical tests have proven that in many cases PMcardio is even more accurate (Oravska, 2022).
- Software products –a group of programs that are interconnected and provide information support, usually for the entire agenda. They can be created as a specific product for a specific customer but more often they are developed for the so-called general customer. The mentioned products help doctors,

networks of medical facilities and other health care providers in the organization of their work, diagnosis and treatment.

- Information systems – represent complex information support for management. In the healthcare sector, they include a large part of information systems designed to cover e.g. one private medical practice, a pharmacy, to those that cover the needs of an entire network of medical facilities. From the point of view of their use, we distinguish, e.g.:
 - Hospital information systems.
 - Outpatient information systems.
 - Laboratory information systems.
 - Pharmacy information systems.
 - Managerial and economic information systems.
 - Specialized information systems and others.
- Health information technology offers many benefits to both patients and healthcare providers:
 - Patients can access information about their health in real-time, they can send their medical information to different healthcare providers, and they can even ask their doctor questions and communicate using a secure email service.
 - Doctors have direct access to information about the patient's health in real-time which allows them to provide safer and more reliable medical care and better mutual coordination.

The informatization of processes within the entire healthcare sector is called " eHealth ". Proper use of eHealth ensures the integrity of an individual's health information which is a key factor in providing proper patient care and services. Thanks to guarantees for the protection of personal privacy, eHealth data analyses also contribute to research and health education. The strategic deployment of eHealth also improves the ability of health systems to plan, budget, and deliver healthcare services and supports the decentralization of health systems.

In the Slovak Republic, however, the functionality and real use of the eHealth system in medical practice suffers from limitations and is underutilized. In order to improve this unfavorable situation, it is necessary for the Ministry of Health and the National Centre for Health Information to comply with the recommendations set by the Supreme Audit Office of the Slovak Republic, prepared on the basis of the inspection of the use of the eHealth system in the Slovak Republic in 2022 (SAO, 2022).

These recommendations include e.g. adoption of the current strategic document covering the field of eHealth, setting measurable indicators of program budgeting, monitoring and evaluation of eHealth projects, establishing a schedule of specific tasks in the field of eHealth, raising citizens' awareness of the practical use of the citizen's electronic health book, and others.

5 Project Monitoring and Tracing Movement and Contacts of Persons in Medical Facilities

Information and an effective information system have an irreplaceable function in the security management processes. Currently, the demands for security and health protection at work and the control of the entry of people into the premises of companies or publicly accessible facilities, various state institutions, school facilities, and other private or state buildings are constantly increasing. A more demanding activity, than checking the entry of the persons, is monitoring and tracing of their movement within the building and its individual spaces. In medical facilities, visitors should observe strict hygiene measures and should only visit the clinic or areas that are necessary and should not have access to other departments.

Monitoring and tracing of persons (movement and contacts with other persons) in publicly accessible spaces, such as:

- hospitals and medical facilities,
 - objects of public administration (e.g. social insurance companies, tax authorities, municipal authorities, offices of self-governing regions),
 - railway/bus/airport terminals, or in areas where the movement of a large number of people is expected,
- is an unexplored field from a legal, economic, technical and security point of view. Also, deployment of monitoring and tracing systems in publicly accessible spaces, or in areas where the movement of a large number of people is expected, can have a fundamental impact in the fight against the spread of viral and bacterial diseases.

Based on these facts, a group of researchers from the Faculty of Security Engineering of the University of Zilina has been working on a solution of the applied research and development project Monitoring and tracing the movement and contact of persons in medical facilities, funded by the Research and Development Support Agency of the Slovak Republic (2021-2024).

The project reflects the need to search for contacts in the event of a pandemic but also other security threats. Contact tracing is one of the main non-pharmaceutical measures to prevent the spread of infection (Filonets et al., 2021). There are several studies describing the contact tracing process (Alarabi et al, 2021). Eames and Keeling (2003) consider contact tracing followed by treatment or isolation as a key control measure in the fight against infectious diseases. It is a form of locally targeted control that has the potential to be highly effective in dealing with a small number of cases. Eames et al. (2007) describe contact tracing as a multi-step process including the diagnosis of an infected person, the processing of all probable contacts of this person, the identification of subsequently infected persons and the repetition of the entire process. González-Cabañas et al. (2021) state that currently deployed mobile applications for contact tracing have failed as an effective solution in relation to the COVID-19 pandemic. Having failed to attract the number of active users needed to achieve effective operation, the research community is challenged to find new ways to lead to effective contact tracing solutions. The authors also offer their own contact tracing solution that uses available geolocation information.

The issue of searching for contacts using mobile applications and legal aspects related to the protection of personal data are dealt with by the following documents issued within the EU:

- eHealth Network. Mobile applications to support contact tracing in the EU's fight against COVID-19, Common EU Toolbox for Member States Version 1.0, 15.04.2020 (EC, 2020a).
- Regulation (EU) 2016/679 of the EP and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) (EP, 2016).
- Commission Recommendation of 8.4.2020 on a common Union toolbox for the use of technology and data to combat and exit from the COVID-19 crisis, in particular concerning mobile applications and the use of anonymized mobility data (EC, 2020b).
- Communication from the Commission Guidance on Apps supporting the fight against COVID 19 pandemic in relation to data protection (2020/C 124 I/01) (EC, 2020c).
- COM (2020) 318 final - Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Short-term EU Health Preparedness for COVID-19 Outbreaks (EC, 2020d).

The main goal of the project is to analyse the legal options, economic, health and security impacts of monitoring people and contacts in health care facilities and then create and apply a system for monitoring and tracing people and their contacts in healthcare facilities with subsequent possible use in publicly accessible premises or areas where the movement of a large number of people is expected. Achieving the main goal of the project is divided into sub-goals shown in Figure 3.

Since the development and debugging of this system takes place in parallel with the stages for testing in laboratory and real conditions, errors are gradually removed and all necessary suggestions are incorporated. For testing in laboratory conditions, a simulation of monitoring people in the premises of the University of Zilina is used. This enables the creation of model situations and real-time testing of the software solution already during SW development. For testing in real conditions, it will be necessary to create a module for real-time data processing for a specific monitoring system (in a specific medical facility). After proper implementation, the solution will be tested in the specific environment.

The originality of the project lies in the collection, processing, storage and visualization of data on the movement of people in a closed space. Act of the National Council of the SR no. 473/2005 allows such monitoring on the basis of paragraph 3i - monitoring of a person's activity in a closed space or in a closed place. This activity falls under the charge of physical protection or operation of a security service which can also be operated for personal use in the form of personal protection. In the event that the conditions established by the law on private security are met, these provisions can be used by persons responsible for tracing contacts during the pandemic or at a time of rapidly spreading communicable diseases, and persons responsible for the protection of the object, both from the point of view of ensuring the security of objects (property) and the security of people (health). Here, it is necessary to highlight the possible use of visualization of the movement of people during the evacuation of the object due to terrorist attacks or for other reasons (natural disasters, etc.). The originality of the project lies in the non-existence of a similar solution at home or abroad. Although partial solutions aimed at hospital staff were implemented, e.g. in the USA but these were more common systems for checking access to buildings. The output of the project will be, among other things, a prototype system for monitoring people and their contacts with other people in medical facilities, with possible use in publicly accessible objects but also in protected objects of critical infrastructure. The output of the project will also be procedures for the distribution of monitoring tags (wearable devices) to employees and visitors, procedures using operational analysis for the deployment of reading devices, a database of measured data on the ranges of reading devices and the resistance of tags to damage. The originality also lies in the visualization of movement and the possible setting of the contact search range.

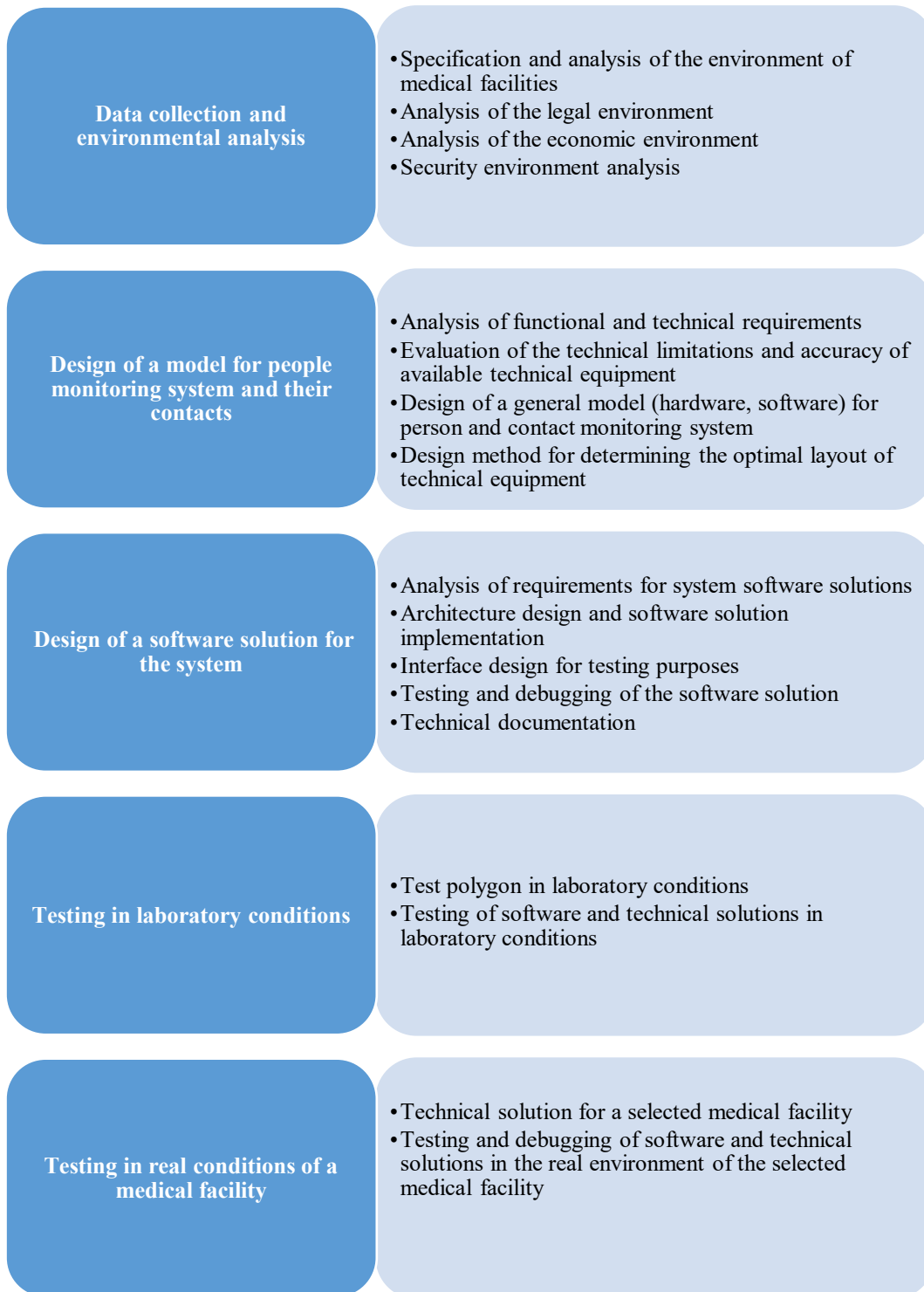


Fig. 3. Sub-goals for achieving the main goal of the project

The uniqueness of the project outputs lies in the variability of their practical implementation. The outputs will be possible to implement not only in medical facilities but also in other spaces with a mass occurrence of people. Considering the development of the global security situation and the actuality of threats of a terrorist attack, the proposed solution has the potential to be used also in the protection of critical infrastructure objects or soft targets.

6 Conclusions

ICT technologies mean a great benefit to healthcare. In medicine, they are used when establishing a diagnosis, when monitoring the condition of patients, when evaluating measurements, as an information system for recording data related to the treatment of patients but at the same time they are also used to ensure the security and protection of medical facilities.

The COVID-19 pandemic has negatively affected the entire world, but on the other hand, it has accelerated the use of new technologies to solve crisis situations. Digital technologies and data have played a significant role in the fight against the crisis caused by the disease COVID-19. From the point of view of preparing for other pandemics as well as solving various crisis situations, the question of further investments comes to the fore, or looking for ways to effectively deal with such negative situations.

The European Commission published on December 12, 2022 Study on lessons learned, best practices, and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic. The study provides a comprehensive overview of the approach and lessons learned from EU-level measures on cross-border interoperability, coordination, implementation, and epidemiological impact of digital contact tracing applications in relation to the disease COVID-19. Digital contact tracing was part of health systems' resilience response to a new situation.

In response to the COVID-19 pandemic, countries around the world have increasingly used digital technologies for contact tracing. There is strong agreement among Member States that EU cooperation through various working groups on digital contact tracing has helped to reduce the burden of cross-border detection of infections. In addition, it provided technical assistance, partner support, and valuable insights and led to a reduction in the cost of implementing and operating several national applications.

In terms of further development and use of contact tracing in the future using digital technologies, several recommendations were defined in the study, which include (empirica, 2023):

- Complement early on conventional with digital contact tracing.
- Develop further and keep up to date the common EU Toolbox.
- Maintain the flexible and dynamic EU collaboration.
- Enhance integration and alignment with overall public health processes.
- Invest in further functionalities.
- Evaluate and monitor from the onset using common indicators.

The aim of these recommendations is to provide support for the ability to deploy digital contact tracing systems in comparable future situations in ways that allow processes and outcomes to be monitored and used by health systems.

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