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Disaster preparedness in critical healthcare organisations

Katasztrófákra való felkészülés az egészségügyi kritikus szervezetekben

Gábor Mongel
Ludovika University of Public Service,
Doctoral School of Military Sciences,
doctoral student
Email: mongel.gabor@semmelweis.hu
ORCID: 0009-0001-9024-5233

Dr. Maxim Kátai-Urbán
Ludovika University of Public Service,
Doctoral School of Military Sciences, lecturer
Email: maximkatai@gmail.com
ORCID: 0000-0001-5079-4644

Dr. István Mészáros
Semmelweis University, Technical Directorate General,
Director General
Email: meszaros.istvan@semmelweis.hu
ORCID: 0000-0002-1555-0705

Introduction

A subset of healthcare institutions falls within the category of critical entities, as any disruption to their operation poses direct risks to society and public health. National and European Union regulations on the resilience of critical entities reinforce the expectation that actors in the healthcare sector must be able to prevent and manage extraordinary events, as well as maintain organisational resilience. The aim of this study is to present the types of extraordinary events that threaten the operations of critical healthcare entities and to examine the organisational and operational factors that influence resilience. This requires professional interpretation of the relevant new legal norms and consideration of the mandatory rules prescribed by the authority. The analysis adopts a comprehensive approach to hospital safety systems and evaluates the impacts of internally and externally generated extraordinary events on the continuity of patient care. The cases presented demonstrate that incidents involving the handling of dangerous substances, fires, gas cylinder events, and extreme weather pose significant risks, particularly when preventive and preparedness measures are insufficient. The study concludes that enhancing the resilience of critical healthcare entities is not solely a technical challenge but also a matter of organisational design, human resource management, and planning. Education and training, risk-based planning, and the regular conduct of exercises jointly contribute to ensuring that healthcare institutions can maintain essential services even under extraordinary circumstances.

Bevezetés

Az egészségügyi intézmények egy része a kritikus szervezetek körébe tartozik, mivel működésük zavara közvetlen társadalmi és közegészségügyi kockázatot jelent. A kritikus szervezetek ellenálló képességére vonatkozó hazai és európai uniós szabályozás megerősíti azt az elvárást, hogy az egészségügyi ágazat szereplői képesek legyenek a rendkívüli események megelőzésére, kezelésére és az ellenállóképesség fenntartására. A tanulmány célja annak bemutatása, hogy milyen típusú rendkívüli események veszélyeztetik az egészségügyi kritikus szervezetek működését, valamint milyen szervezeti és üzemeltetési tényezők befolyásolják az rezilienciát. Ehhez szükséges a vonatkozó új jogi normák szakmai értelmezése, valamint a hatóság által előírt, kötelezően alkalmazandó szabályok figyelembe vétele.

A vizsgálat a kórházak biztonsági rendszerét komplex megközelítésben értelmezi, és elemzi a belső és külső eredetű rendkívüli események hatásait a betegellátás folytonosságára. A bemutatott esetek rávilágítanak arra, hogy a veszélyes anyagok kezelése, a tűzesetek, a gázpalackokkal kapcsolatos események, valamint az extrém időjárási jelenségek egyaránt jelentős kockázatot hordoznak, különösen akkor, ha a megelőző és felkészülési intézkedések hiányosak. A tanulmány következtetése szerint az egészségügyi kritikus szervezetek ellenállóképességének növelése nem kizárólag műszaki kérdés, hanem szervezési, humánerőforrás és tervezési feladat is. Az oktatás, a kockázatalapú tervezés és a gyakorlatok rendszeres végrehajtása együttesen járul hozzá ahhoz, hogy az intézmények rendkívüli helyzetekben is képesek legyenek alapvető szolgáltatásaik fenntartására.

Kulcsszavak: egészségügyi kritikus szervezetek, kórházbiztonság, ellenállóképesség, rendkívüli események, kockázatalapú tervezés, oktatás, gyakorlatok

Keywords: critical healthcare entities, hospital safety, resilience, extraordinary events, risk-based planning, education and training, exercises

Legal framework of resilience in the healthcare sector and the hospital safety system

Member States of the European Union must identify critical entities that provide services essential to maintaining vital functions related to public security and public health, society, the environment, or the economy, as well as situations in which an event would significantly disrupt these essential services. The healthcare sector includes healthcare service providers, manufacturers of pharmaceutical active ingredients and critical medical devices, and the research and development of new medicinal products. [1] The healthcare sector—including, among others, healthcare service providers—must prevent events caused by natural disasters or man-made threats such as terrorism or sabotage, effectively implement protective measures, and ensure effective responses, resistance, mitigation and attenuation of impacts, adaptation, and recovery. In other words, the sector must remain resilient. [2]

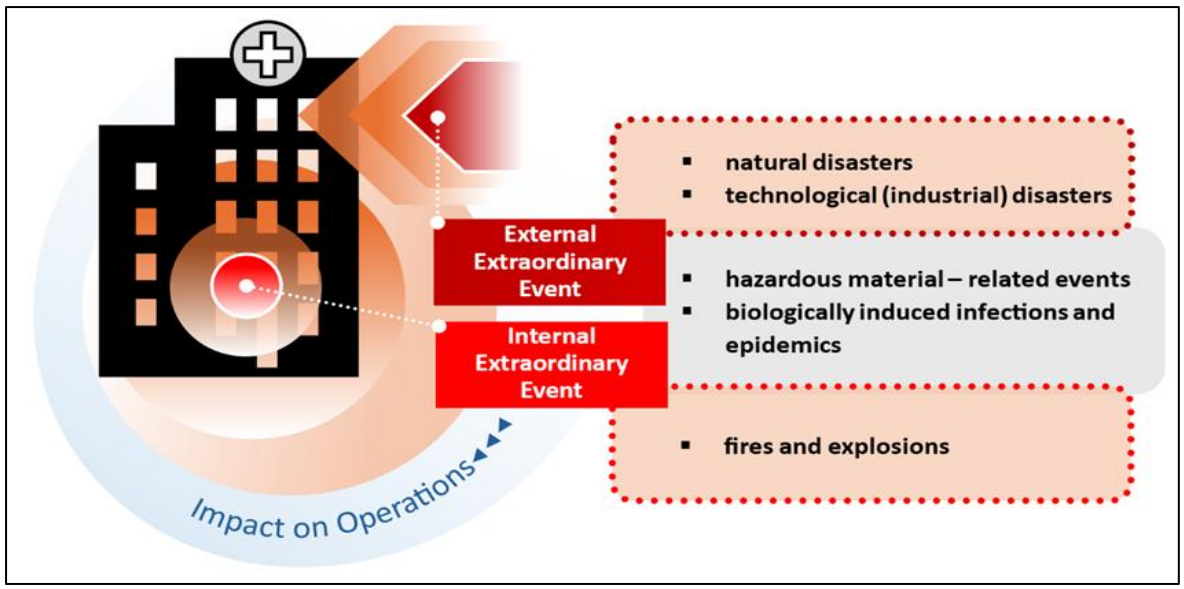
Act LXXXIV of 2024 on the resilience of critical entities defines the essential services provided by critical entities that are indispensable for maintaining Hungary's economic and social stability, ensuring national security, strengthening the national resilience system, protecting the environment, maintaining defence capabilities, and safeguarding public health. The law clearly stipulates that critical organisations shall develop their risk assessments, resilience matrices, and resilience measures, taking into account the national risk assessment. [3:5.§ (2)] Based on its external and internal environment, it assesses, identifies, evaluates, and manages all risks that may affect the secure and continuous operation of critical organisations and critical infrastructure, as well as the continuity of essential services. The risks to be examined during risk assessment and in the preparation of the resilience matrix may include mandatory general and sectoral risks, as well as other risks identified by the organisation. When conducting risk assessments and preparing resilience matrices, attention must be paid to all consequences of risks that threaten the secure and continuous operation of critical organisations and critical infrastructure, and that could lead to an extraordinary event. The detailed aspects of risk assessment and the preparation of the resilience matrix are specified by a government decree in Hungary. [3:18.§] [4] It is important that, during planning, the resilience plan includes at least the following elements relating to critical organisations and critical infrastructure: risk identification, risk assessment, resilience matrix, and, taking these into account, the measures whose development and operation ensure the continuity of essential services and the restoration of operations. [3:19.§ (4) c] It should be emphasised that the manager responsible for the critical organisation's resilience must prepare the risk assessment and resilience matrix and keep them up to date. [3:20.§ (4) c]

In order to improve the resilience of critical organizations and critical infrastructure, the head of the critical organization shall, using the resilience matrix and risk analysis methodology guide published on the website of the general designating authority and taking into account the national risk assessment, on the initiative of the head responsible for the resilience of the critical organization, assesses and documents the threats and risks to the critical organization and critical infrastructure that could lead to an extraordinary event. The harmful effects and extent of the identified threats, the probability of their occurrence, and the degree of exposure must be determined, and the resilience preparedness of the critical organisation and critical infrastructure must be examined. Measures must be taken to improve security. The critical organisation shall apply the following risk management solutions to the identified risks: risk reduction through the introduction and implementation of protective measures; risk avoidance; risk transfer; and risk acceptance. The critical organisation shall document and communicate the results of the risk analysis within the organisation to the extent necessary. Risks affected by risk management shall be justified by the manager responsible for the resilience of the critical organisation. The critical organisation shall continuously monitor the circumstances affecting the risks and keep the resilience matrix up to date. The general and sector-specific structure of the resilience matrix shall take into account at least the following main topics: meteorological risks, geological risks, human risks, technical risks, technological risks, fire risks, IT risks, risks related to hazardous materials and technologies, and sector-specific risks. IT risks in the case of essential services relate to the digital operational resilience of the financial sector and the amendment of Regulations (EC) No 1060/2009, (EU) No 648/2012, (EU) No 600/2014, 909/2014/EU and (EU) 2016/1011, as specified therein. [4:15. §] When analysing risks, it is also important to note that knowledge of the relevant rules is essential, which is why the general designating authority has published a mandatory risk analysis matrix as an aid. [5] Within the healthcare sector, the affected subsectors have also been specified—similar to the approach applied to vital system elements under Act CLXVI of 2012; however, the currently effective legislation not only redefines the subsectors but also provides detailed specifications of the relevant essential services. [6][7] The areas of protection related to hospital safety include occupational safety, environmental protection, fire protection, asset protection, civil protection [8], and radiation protection. Cybersecurity has emerged as a relatively new field. These protective disciplines are present throughout the system, from the macro-environment down to the direct processes of patient care. In the context of disaster management and civil protection, the regulatory requirements of the macro-environment are integrated into patient care processes through healthcare emergency preparedness planning. Consequently, the requirements for responding to risks and extraordinary events arising in both the micro- and macro-environments are incorporated into healthcare emergency care processes, which differ in approach from those applied under normal operating conditions. [9]

Extraordinary events in critical healthcare entities

Disasters can be classified by origin as natural or man-made (technological or civilizational). Healthcare facilities, and hospitals in particular, constitute part of the critical infrastructure from both technical and societal perspectives. [10] When extraordinary events are classified from the perspective of critical healthcare entities, a distinction can be made between external and internal extraordinary events that negatively affect the operation of a given organisation and thereby jeopardise the continuity of care. External extraordinary events clearly include natural disasters, which may result in impacts ranging from minor power outages to the complete operational incapacity of the affected institution. This category also includes industrial disasters whose effects extend beyond the boundaries of hazardous facilities, a characteristic example being the Bhopal industrial disaster. An examination of internal extraordinary events in healthcare institutions indicates that the majority of fires or explosions typically originate within the institution due to non-compliant behaviour, improper work processes, or accidents.

Events related to dangerous substances, as well as biologically induced infections and epidemics, may constitute both internal and external extraordinary events. The above classification is illustrated in Figure 1.



1. figure: Elements, Interconnections and Position of Hospital Safety within Patient Care (Source: author's own figure)

Events Related to Dangerous Substances

Dangerous substances are regularly used and generated within critical healthcare entities. [11] Chemically hazardous substances are used in both patient care and related research activities. Based on a targeted inspection of carcinogenic, mutagenic, and reprotoxic (CMR) substances conducted at 34 clinics and institutes in Budapest, covering 106 workplaces, it was established that the annual use of formaldehyde is significant (approximately 2,300 litres per year across the 34 institutions). Although these quantities are not comparable to those used in industrial settings, even incidents involving small amounts of hazardous substances may have a considerable impact on the operation of a healthcare organisation. For example, on 9 November 2009, at a clinic in Budapest, formaldehyde is presumed to have come into contact with hydrochloric acid in a basement storage area, resulting in the formation of a pungent gas that necessitated the evacuation of 15 individuals from the building. The internal investigation could not conclusively determine whether the incident was caused by material fatigue of the storage container or by staff negligence. [12] This event did not affect patient care, partly due to the location (basement, operational area). In contrast, in a hospital in Seoul, the leakage of only one litre of nitric acid on the second floor required the evacuation of 700 healthcare workers and 400 patients [13], while in a hospital in London, 150 persons had to be evacuated on 14 August 2025 due to the presumed mixing of chemicals in an operational area, which resulted in the formation of chlorine gas. [14] These cases clearly illustrate that extraordinary events do not necessarily occur during the use of hazardous substances, but may also arise during their storage as waste if this is not carried out with adequate care and expertise.

Fire Incidents

Fire incidents may also occur within critical healthcare entities as internal extraordinary events. Their occurrence can often be attributed to non-compliant behaviour, which may involve not only employees but also patients. An example is smoking in prohibited areas, which led to a fire on 17 March 2024 in a wooden-structured, metal-clad outdoor passageway connecting two clinical buildings in Budapest, affecting an area of approximately 40 square metres. [15]

Fires may also occur due to improper work organisation, as demonstrated by the fire on 18 April 2023 at a hospital in Beijing, which killed 29 people. The fire broke out during renovation works in part of the building due to parallel activities by two subcontractors: a walking surface was being coated with epoxy resin while spark-generating work was simultaneously carried out in the same area. The epoxy resin vapours, combined with fire-hazardous activities, led to a fire, the effective suppression of which was hindered by the failure of the installed sprinkler system to discharge water, raising questions about the facility operator's responsibility. [16] When addressing hospital fires, particular attention must be given to the fact that during the COVID-19 pandemic, the risk of fire significantly increased in the intensive care units of coronavirus hospitals. This was due partly to overloaded electrical systems and partly to the extensive use of oxygen cylinders during patient care. [17] The use of such equipment was closely linked to the nature of the disease, as large numbers of patients with respiratory conditions overwhelmed healthcare facilities, leading to a substantial increase in the number of mobile medical oxygen cylinders and ventilators in use. During the pandemic, fires in institutions with such profiles were frequent worldwide.

Events Related to Gas Cylinders

Medical gas supply systems, and gas cylinders in particular, may contribute to the occurrence of fires and, in extreme cases, explosions within healthcare institutions. In this sector, medical oxygen is the most common use, and the number of cylinders used simultaneously depends on the institution's profile—for example, significantly fewer gas cylinders are present in psychiatric facilities than in pulmonology-focused institutions. Extraordinary events involving gas cylinders can cause substantial damage to an institution's infrastructure, hindering the effective reconstruction of the sequence of events and the identification of root causes. A notable example is the detonation that occurred on 13 November 1979 in the city of Parma, Italy, resulting in 24 fatalities, caused by a gas cylinder explosion at the Maggiore Hospital. As a consequence of the incident, one wing of the hospital was completely destroyed, and even a 15-year judicial investigation failed to conclusively determine whether the disaster was caused by a faulty assembly of the gas cylinder or by the use of a cylinder filled with a flammable gas instead of oxygen. [18]

Events Related to Extreme Weather

The occurrence of natural disasters affecting individual critical healthcare entities is strongly influenced by the institution's geographical location. While healthcare facilities in Budapest may be affected by storms and minor flash floods, as occurred in the early morning hours of 9 June 2025 [19], institutions in the United States, for example, may face challenges caused by hurricanes. In such situations, the security of uninterrupted operation may be compromised by the combined effects of multiple events, including elevator failures, water ingress, power outages and other electrical issues, downed power lines, and broken windows.

Prevention and mitigation of disasters

To ensure continuous operation and resilience, critical healthcare entities must be prepared for externally originating adverse impacts and strive to prevent internal extraordinary events in response to disasters and extraordinary incidents affecting them, as described above, through the following measures.

Education and Training: Appropriate preparation and training for employees regarding extraordinary events is indispensable. A good example is the training of healthcare and technical staff in the fundamentals of gas cylinder handling, during which personnel responsible for operating such pressure vessels become familiar with the basic properties of different gas types, appropriate conduct to be observed during transport, handling and storage, as well as the basic management of emergency situations.

It is essential that such training programmes be concluded with appropriate knowledge assessment (examinations), enabling the verification of actual competence. [20] This requirement is equally applicable in the field of fire protection and in relation to the handling of hazardous chemical substances.

Risk Assessment and Planning: Operational safety responsibilities include preparedness for extraordinary events, advance planning for crisis responses, ensuring the continuity of operations, and recovery. If, as a result of extraordinary events, healthcare demands and capacities become disproportionately misaligned, patient care is conducted in accordance with the rules of crisis healthcare provision. [21] Resilience Plans focus not only on protection but also explicitly on resilience. In developing any plan, the first step is to define objectives and identify the risks that influence their achievement. [22] For critical healthcare infrastructure elements, resilience planning must be based on the healthcare emergency planning framework.

Exercises: The exercising of plans and of situations generated by specific extraordinary events is essential for verifying the realism of the developed plans and, in addition to education, for the practical training and preparedness of employees. Such exercises may include simulating internal extraordinary events (e.g., fires) or external extraordinary events (e.g., accidents involving the transport of dangerous substances or natural disasters). Plans play a key role in the design of exercises, enabling the precise definition of objectives, the identification and management of risks, the involvement of relevant stakeholders (both internal and external), the clarification of responsibilities, and the establishment of timelines. An important part of activities related to extraordinary situations should also include protection against external intentional interventions, where the roles of disaster management and industrial safety can be decisive [23].

Conclusions

With regard to critical healthcare entities, both external and internal extraordinary events can be identified that negatively affect organisational operations and jeopardise the continuity of patient care. In order for institutions to be adequately prepared for such events, it is essential that they are aware of their exposures, possess appropriate plans, and have properly trained personnel available to manage these situations effectively. The key elements of such preparedness—alongside planning—are education and the organisation of exercises.

References

[1] EUR-Lex. A kritikus szervezetek rezilienciájának fokozása. [Online]. Elérhetőség: https://eur-lex.europa.eu/HU/legal-content/summary/making-critical-entities-more-resilient.html (2025.12.18.)

[2] Az Európai Parlament és a Tanács (EU) 2022/2555 irányelve (2022. december 14.) az Unió egész területén egységesen magas szintű kiberbiztonságot biztosító intézkedésekről, valamint a 910/2014/EU rendelet és az (EU) 2018/1972 irányelv módosításáról és az (EU) 2016/1148 irányelv hatályon kívül helyezéséről (NIS 2 irányelv) [Online]. Elérhetőség: https://eur-lex.europa.eu/eli/dir/2022/2555/oj?locale=hu (2025.12.18.)

[3] A 2024. évi LXXIV. törvény a kritikus szervezetek ellenálló képességéről [Online]. Elérhetőség: https://njt.hu/jogszabaly/2024-84-00-00 (2025.12.18.)

[4] A 474/2024. (XII.31.) Korm. rendelet a kritikus szervezetek ellenálló képességéről szóló törvény végrehajtásáról [Online]. Elérhetőség: https://njt.hu/jogszabaly/2024-474-20-22 (2025.12.18.)

[5] Általános kijelölő hatóság által közzétett, kötelezően alkalmazandó kockázatelemzési mátrix [Online]. Elérhetőség: https://www.katasztrofavedelem.hu/application/uploads/documents/2025-06/EKM-minta_01_2025.xlsx (2025.12.18.)

[6] Christián L.; Mészáros I., Kátai-Urbán M., Simon M., Palicz T., Tiszolczi B. G., Tóth, J. J. "The Basis and Practice of Crisis Communication for Critical Health Infrastructure in Selected Institutions of the Hungarian Health Sector" Kome: An International Journal of Pure Communication Inquiry 13 : 2 pp. 67-94., 28 p. (2025) [Online]. Elérhetőség: https://real.mtak.hu/222368/1/KOME_OF_29_Christian_Laszlo_et_al.pdf (2025.12.18.)
[7] Kátai-Urbán L., Bleszity J., Vass Gy. "A kritikus infrastruktúra védelmi felsőoktatási tapasztalatok a kritikus szervezetek ellenállóképességéről szóló szabályozás tükrében" Polgári Védelmi Szemle XVII.: 2025 Különszám pp. 220-236., 17 p. (2025) [Online]. Elérhetőség: https://mpvsz.hu/pv_szemlek/pvszemle2025/index.html (2025.12.18.)
[8] Muhoray Á. "A polgári védelem helye a modern katasztrófavédelemben, Hadmérnök 12: 2 p. 188 (2017) http://hadmernok.hu/172_15_muhoray.pdf (2025.12.18.)
[9] Mészáros I. "A fekvőbeteg-ellátással foglalkozó egészségügyi létfontosságú rendszerelemek komplex üzemeltetői biztonságának kutatása és fejlesztése, különös tekintettel az egészségügyi válsághelyzet-tervezési feladatok ellátására" PhD értekezés, Katonai Műszaki Doktori Iskola, Nemzeti Közszolgálati Egyetem, Budapest, Magyarország, 2024 [Online]. Elérhetőség: https://m2.mtmt.hu/gui2/?mode=browse&params=publication;35634186 (2025.12.18.)
[10] Veresné Rauscher J., Berek L. "Kórházak biztonsága és védelme I.: Kockázati tényezők és lehetséges következmények" Hadmérnök 16: 4 pp. 13-24., 12 p. (2021) [Online]. Elérhetőség: https://folyoirat.ludovika.hu/index.php/hadmernok/article/view/5531 (2025.12.18.)
[11] Mongel G. "Evolution and Practical Application of Critical Infrastructure Protection Planning Requirements for Healthcare" American Journal of Research Education and Development 2025 : 3 pp. 69-90. , 22 p. (2025) [Online]. Elérhetőség: https://red.devlart.hu/issues/2025_3.pdf (2025.12.18.)
[12] Belső kivizsgálás dokumentumai alapján.
[13] 1,100 evacuated from hospital after nitric acid leak [Online]. Elérhetőség: https://www.koreatimes.co.kr/southkorea/20141029/1100-evacuated-from-hospital-after-nitric-acid-leak (2025.12.18.)
[14] Several people treated following chemical spill at Guy's Hospital [Online]. Elérhetőség: https://www.itv.com/news/london/2025-08-14/several-people-treated-following-chemical-spill-at-guys-hospital?utm_source (2025.12.18.)
[15] Belső kivizsgálás dokumentumai alapján.
[16] China releases Beijing hospital fire investigation report [Online]. Elérhetőség: https://english.www.gov.cn/news/202310/25/content_WS65390c02c6d0868f4e8e0a6e.html (2025.12.18.)
[17] Hospital fires from intense use of oxygen for Covid-19 patients [Online]. Elérhetőség: https://ec.europa.eu/newsroom/jrc_drm/items/715147/en (2025.12.18.)
[18] 13.11.1979. Salta in area il padiglione Cattani dell'ospedale [Online]. Elérhetőség: https://www.igiornidiparma.it/13-11-1979-salta-in-area-il-padiglione-cattani-dellospedale/ (2025.12.18.)
[19] Viharkárok a Semmelweis Egyetemen: több mint 100 bejelentés érkezett [Online]. Elérhetőség: https://semmelweis.hu/hirek/2015/07/09/viharkarok-a-semmelweis-egyetemen-tobb-mint-100-bejelentes-erkezett/ (2025.12.18.)
[20] Gázpalack- és reduktorkezelés [Online]. Elérhetőség: https://semmelweis.hu/biztonsag/files/2024/02/5_Gazpalack-es-reduktorkezeles-oktatasi-anyag_2024.pdf (2025.12.18.)
[21] Mészáros I. "A kórház – mint kritikus infrastruktúra – biztonságának aktuális kérdései" Belügyi Szemle (2010-) 71 : 6 pp. 1059-1072. , 14 p. (2023) [Online]. Elérhetőség: https://belugyiszemlejournal.org/index.php/belugyiszemle/article/view/1265 (2025.12.18.)

[22] Baloghné Pruha M. A. (2024). Tervek és gyakorlatok szerepe a kritikus szervezetek ellenálló képességének fejlesztésében. Védelem Tudomány a Katasztrófavédelem Online Szakmai, tudományos folyóirata, 9 (ksz.), 9-13 [Online]. Elérhetőség: https://ojs.mtak.hu/index.php/vedelemtudomany/article/view/17901 (2025.12.18.)
[23] Almási Cs., Christián L., Kátai-Urbán L., Vass Gy. "Security Planning in Transport of Dangerous Goods by Road in Hungary". In: Michal, Titko; Erika, Mošková; Katarína, Košútová (szerk.) Riešenie Krízových Situácií v Špecifickom Prostredí : zborník príspevkov z 25. vedeckej konferencie s medzinárodnou účasťou. Zilina, Szlovákia: Žilinská univerzita v Žiline (2022) 150 p. pp. 12-18.