DISSERTATION FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PHD)

Health indicators of the Hungarian population concerning the activities of the National Ambulance Service

by Máté Sándor Deák, JD

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DOCTORAL SCHOOL OF HEALTH SCIENCES

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List of abbreviations

ALS Advanced Life Support

AMI Acute Myocardial Infarction

BLS Basic Life Support

BÖME Budapesti Önkéntes Mentő Egyesület

CCU Coronary care unit

COVID-19 SARS-CoV-2 Coronavirus disease

CPR Cardiopulmonary Resuscitation

ED Emergency Department

EHR Electronic Health Record

EMS Emergency Medical Services

EMT Emergency medical technician

EU European Union

GIS Geospatial Information Systems

ICP Integrated Care Pathway

ICU Intensive Care Unit

NAS Hungarian National Ambulance Service

NUTS 3 Nomenclature of Territorial Units for Statistics at level 3

OHCA Out-of-Hospital Cardiac Arrest

PCI Percutaneous Coronary Intervention

POST Patient Off Stretcher Time

SMR Standardized Mortality Ratios

SOP Standardised Operational Procedures

R Virus Reproduction Rate

I. Introduction

I.1. Health indicators of Hungary

Health metrics in Hungary rank among the poorest within the European Union. Life expectancy for both men and women are lower than the average for the EU-27 countries; infant and maternal mortality rates are higher than in other EU countries. Life expectancy at birth increased by nearly two years between 2010 and 2019 before declining in the first two years of the pandemic. However, even with the increase before the COVID-19 pandemic, it has yet to catch up with many of the more developed countries in the EU. Life expectancy in good health (61.7 years) was almost eight years below the EU average in 2009 [1].

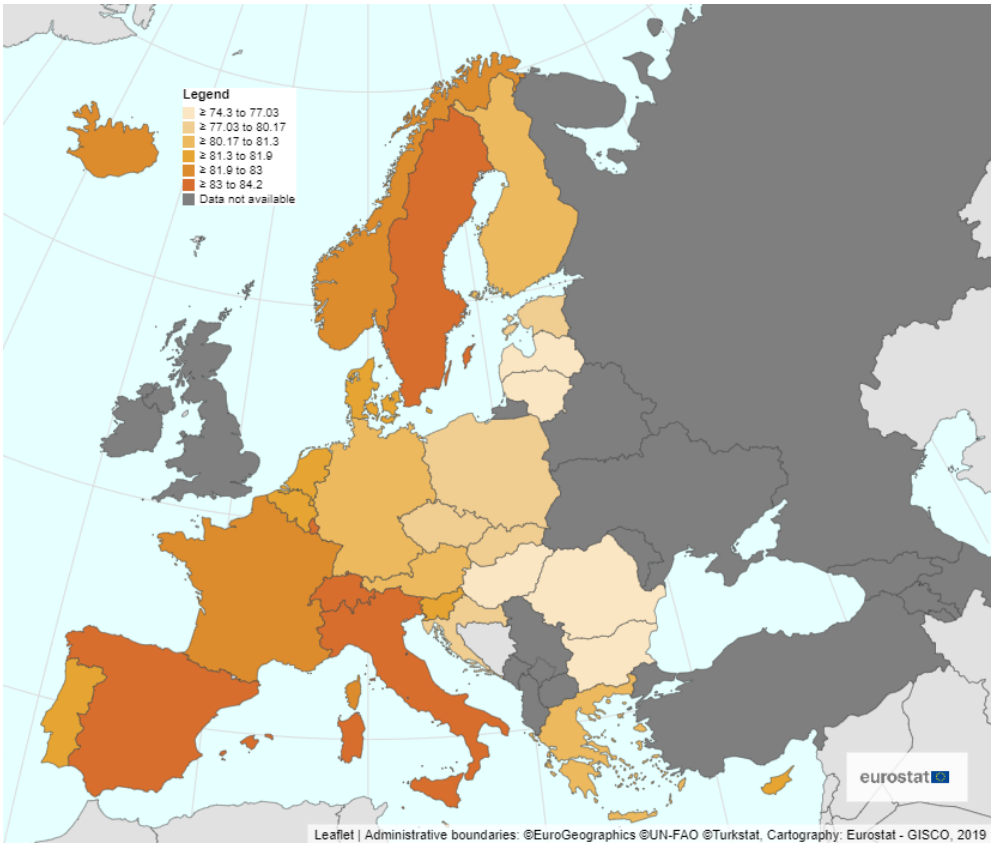

Figure 1. Life expectancy in Europe, 2019 (Eurostat, 2022)

Regarding preventable and avoidable mortality, Hungary ranked second to last in the EU-27 in 2019, ahead of Romania [1]. In 2019, around 40% of the adult population in Hungary had at least one chronic disease. Nevertheless, substantial disparities are evident across income brackets, as evidenced by the fact that while 30% of individuals in the highest income quintile report having at least one chronic illness, this figure escalates to 46% among those in the lowest income quintile [1].

According to the most recent Eurostat data, Hungary ranks among the European Union countries most severely affected by cardiovascular diseases. Positioned just after Lithuania, Hungary exhibits one of the highest standardised death rates for ischemic heart diseases. Furthermore, it records the highest prevalence of self-reported hypertensive disorders within the EU. [2].

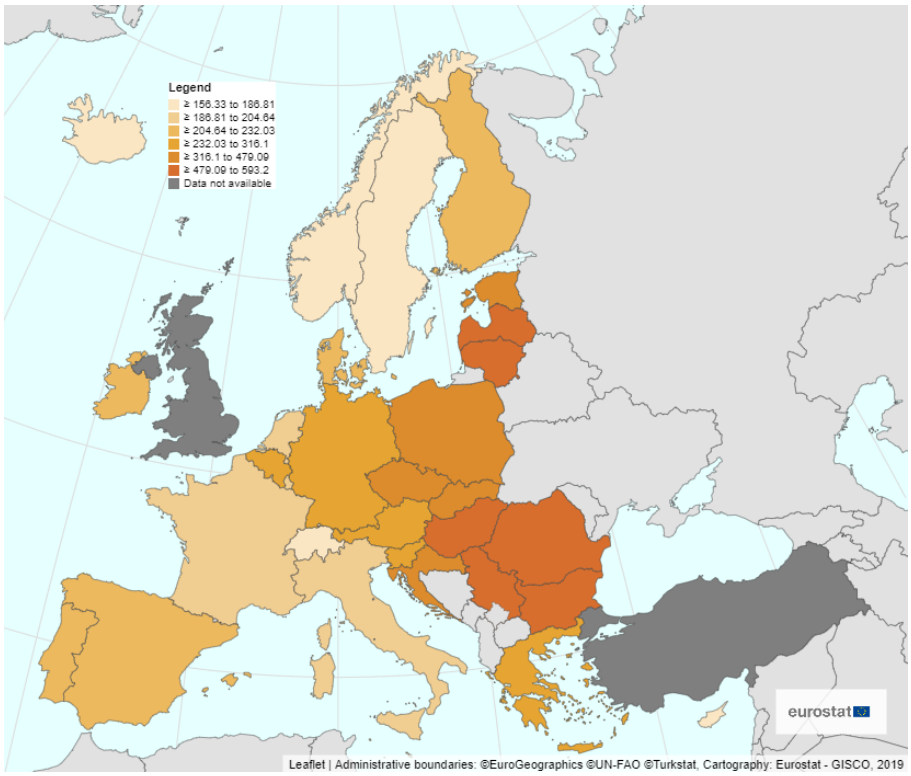

Figure 2. Preventable and avoidable mortality in Europe, 2019 (Eurostat, 2022)

Around half of all deaths in Hungary are attributable to lifestyle risk factors, the most important of which are smoking, unhealthy diet, excessive alcohol consumption and lack of regular physical activity. A multitude of elements contribute to the suboptimal health outcomes observed in Hungary. These encompass limited accessibility to healthcare services, deficiencies in the quality of healthcare, inadequate sanitation, and elevated poverty levels in certain regions. Experts have noted that the gate-keeping mechanism within the healthcare system, designed to manage access to specialised services and resources, is frequently either ineffectively executed or exists mainly in name only [3]. Evidence indicates a suboptimal utilisation of resources within the Hungarian healthcare system, attributable to inefficient management. This issue, along with the dated structure of the system, has been a subject of intense professional and policy debate since the mid-1990s. Health policy experts have repeatedly expressed concerns about the system's organisational structure and operational efficiency. A salient feature of the Hungarian healthcare system is its significantly high number of acute care hospital beds compared to international standards. Furthermore, the system is marked by regional disparities in healthcare access, a conflation of different levels of progressive care, and a disjointed emergency service framework. These characteristics are compounded by inconsistent emergency room access, varying healthcare quality, and a conspicuous lack of utilisation of modern health technologies, including day surgeries, minimally invasive procedures, and telemedicine. These factors underscore an urgent need for comprehensive reforms in Hungary's healthcare system [4].

Cumulatively, these various elements result in a comparatively substandard health status in Hungary relative to other European Union nations. Consequently, Hungarian policymakers must address these concerns to enhance the population's health.

I.2. Amenable mortality

Amenable mortality, despite being less recognised, possesses the potential to yield an accurate representation of healthcare systems. It offers valuable insights to healthcare providers and decision-makers across various tiers, enriching their understanding and guiding informed decision-making [5,6]. “A death can be considered amenable if it could have been avoided through optimal health care”. It should not be confused with preventable mortality, which is” … broader and includes deaths which could have been avoided by public health interventions focusing on wider determinants of public health, such as behaviour and lifestyle factors, socioeconomic status and environmental factors.” [1]. In 2018, a research team from Spain developed a suite of indicators specifically designed to assess amenable mortality [7]. These indicators encompassed only those disorders identifiable solely through symptomatic diagnosis, positing that timely and adequate treatment of these conditions could significantly enhance patient health outcomes. The primary diseases surrounded by these indicators are detailed in Table 1.

Table 1. Amenable mortality causes identified by the Spanish research [7]

Cause of death	Age	ICD-9
Tuberculosis	0-74	010-018 137
Immunizable diseases	0-74	032, 033, 037, 045, 055, 056, 070.0, 070,1, 070.2-070.3, 072
Pneumonia, acute respiratory infections, influenza	0-74	460-466, 480-486, 487
Skin cancer (melanoma and no-melanoma)	0-74	172,173
Breast cancer (women)	0-74	174
Cervical cancer	15-74	180
Uterine cancer	15-74	182, 179
Testicular cancer	0-74	186
Hodgkin's disease	0-74	201
Leukemia	0-14	204-208
Pernicious anemia	0-74	280-281
Thyroid diseases	0-74	240-246
Diabetes mellitus	0-49	250
Cerebrovascular diseases	0-74	430-438
Chronic rheumatic cardiovascular disease	0-74	393-398
Hypertension	0-74	401-405
Ischemic heart disease	35-74	410-414
Asthma	5-49	493
Peptic ulcers	0-74	531-534
Appendix diseases	0-74	540-543
Abdominal hernia	0-74	550-553
Cholelithiasis/cholecystitis	0-74	574-575
Benign prostate hyperplasia	0-74	600
Perinatal mortality		760-779
Maternal mortality	All	630-676
Congenital cardiovascular anomalies	0-74	745-747
Adverse events occurred during medical and surgical intervention	All	E870-879

ICD: international classification of diseases; data sorted by ICD-10th codes.

The combination of amenable mortality and preventable mortality is called avoidable mortality. Amenable mortality research is essential to understand the healthcare system's effects on health outcomes. Preventable mortality is a "composite indicator of age- and cause-specific rates". Age-specificity is defined as mortality before age 75, while cause-specificity is defined as the subgroups. 'Preventable mortality' is the type of mortality that is “preventable by the best-known public health interventions”, i.e. reflecting primarily healthy lifestyle behaviour.

In contrast, 'treatable mortality' is the type of mortality that is 'best managed by timely medical intervention', focusing on the impact of the health care system and the quality of care. The list of causes has grown steadily over the last decades, as can be seen from the definition, as advances in science have made it possible to prevent and treat new diseases. In the context of amenable mortality, Hungary ranks unfavourably among European Union nations [8]. A Hungarian study published in November 2010 examined healthcare-amenable mortality trends, revealing that in 2006, the years of potential life loss per 100,000 for males stood at 7,207 and 3,870 for females in Hungary. Despite a declining trend, amenable mortality remains a significant contributor to this number, accounting for approximately one-third of both male and female life loss. Consequently, reducing amenable mortality rates would substantially contribute to the decrease in avoidable deaths. The Hungarian analysis revealed a higher amenable mortality rate for Hungary than other EU countries, which indicates there needs to be an additional focus on amenable mortality to increase healthcare quality and reduce avoidable deaths.

In addition, further research needs to be conducted to identify measures that can effectively minimise amenable mortality rates in Hungary and the rest of Europe. Nevertheless, these findings provide crucial insight into how amenable mortality should be addressed in the future and could potentially lead to improved health outcomes across Europe.

Despite the substantial progress, disparities in amenable mortality between different population groups and geographical regions in Hungary remain. For example, an analysis of causes of death has revealed that individuals from deprived backgrounds are more likely to experience preventable deaths due to conditions such as circulatory diseases, diabetes, and mental health problems than those from privileged backgrounds. Similarly, a more significant burden is experienced by rural populations compared with urban areas, suggesting that further efforts should be taken to improve healthcare access and quality for all citizens. Hungary is among the highest in the EU in terms of both preventable and avoidable death rates with appropriate treatment, according to the 2021 State of Health in the EU Health Country Profile. Based on data for 2018, the preventable mortality rate is more than double the EU average (326 per 100,000 population), putting Hungary at the bottom of the list. In this case, the leading causes of death are lung cancer, ischaemic heart disease and alcohol-related diseases. Avoidable deaths with appropriate treatment are also double the EU average (176 per 100,000 population), ranking fifth worst among the 27 Member States. The leading causes of death are cardiovascular diseases and cancers (colorectal and breast cancer). Undoubtedly, intervention and transformation are essential throughout the system to improve health and life expectancy.

To conclude, amenable mortality must remain prioritised to ensure optimal health outcomes throughout Europe. Research has indicated that Hungary has a higher amenable mortality rate than other EU countries, and further research is needed to identify ways of reducing amenable mortality rates. This research provides a valuable opportunity to develop more effective healthcare systems that can ultimately lead to better health outcomes. Moreover, as previously indicated, the study elucidates that approximately one-fourth of premature mortality in Hungary is attributable to amenable deaths stemming from inadequate healthcare provision [9]. Consequently, it is imperative to investigate the underlying causes and develop strategic interventions, enabling decision-makers to minimise the incidence of avoidable mortalities to the greatest extent possible.

I.3. The study's position in the chain of survival/healthcare chain?

The integration of prehospital and hospital healthcare systems is essential for delivering comprehensive emergency medical services. This theoretical framework involves understanding the mechanisms, protocols, and operational strategies that enable efficient and effective patient care from the moment an emergency occurs until the patient is stabilised in a hospital setting [10]. Prehospital care serves as the frontline defence in medical emergencies, significantly impacting patient outcomes through timely and appropriate interventions. The hospital care system subsequently ensures the continuation of care, facilitating recovery and rehabilitation. This integrated approach is crucial for addressing acute medical conditions, reducing morbidity and mortality, and optimising healthcare resource utilisation [11].

Prehospital healthcare: the first line of defense

Prehospital healthcare encompasses all medical services provided to patients before they arrive at a hospital. This phase of care is critical for stabilizing patients, managing acute conditions, and preparing them for further treatment. The primary components of prehospital healthcare are the Emergency Medical Services (EMS). EMS is a network of services coordinated to provide immediate medical care and transportation to patients experiencing acute health crises. This includes ambulance services, paramedics, and emergency medical technicians (EMTs). EMS systems are designed to respond rapidly to emergencies, providing on-site medical interventions and ensuring timely transport to healthcare facilities.

Ambulance services form the backbone of prehospital care, equipped with medical tools and staffed by trained personnel capable of delivering life-saving treatments. Ambulances are categorised based on their capabilities, ranging from basic life support (BLS) units to advanced life support (ALS) units, which can perform more complex medical procedures. The interventions provided during the prehospital phase include basic life support measures (e.g., CPR, bleeding control), advanced life support techniques (e.g., defibrillation, intubation), and the administration of medications. [12] The goal is to stabilise the patient's condition, manage pain, and prevent further deterioration before reaching the hospital. Effective triage protocols are essential for assessing the severity of the patient's condition and prioritising care based on urgency. Transport decisions are equally crucial, determining whether patients are taken to specialised care centres, such as trauma, stroke, or cardiac centres, which can significantly impact outcomes. This area is unique in many ways; there is only a minimum diagnostic background, and in many cases, the staff only get to know the exact problem after arriving on site. In addition, many situations could be generally dangerous for the first responders, so they need a different state of mind. Nevertheless, despite the difficulties, a well-organised ambulance service could help fight against morbidity because a patient's survival and recovery depend largely on when they get professional healthcare help [13,14]. Frequently, even layperson assistance can significantly enhance survival prospects, ranging from basic measures like bleeding control and simple dressings to more advanced actions such as immobilisation of body parts and resuscitation. Nevertheless, the outcomes are predominantly contingent upon the timeliness of initiating advanced-level professional intervention.

Globally, ambulance services are confronted with numerous challenges, among which the increasing utilisation of these services for primary care issues is a burgeoning concern [15]. The efficacy of this assistance predominantly hinges on the proficiency of the ambulance service in question, underscoring the importance of scrutinising the performance of specific service providers. Various studies have been conducted internationally on this subject. However, it is noteworthy that these investigations have predominantly focused on organisations functioning in a market or semi-market framework, particularly in Anglo-Saxon countries, without exception. A 2017 research study in the United States sought to elucidate the geographic disparities in ambulance transport to emergency departments (ED) among Medicare beneficiaries, with a particular focus on health status, socioeconomic status, and the availability of providers. Utilising Medicare claims data from 2010 for individuals aged 66 and above, the study identified a national rate of ambulance transport at 22.2 per 100 person-years, with 36.7% of ED visits involving ambulance transportation. Notably, there was considerable geographic variation in ambulance use. Regions within the top quartile exhibited a 75% higher rate of ambulance transport and a 15.5% greater proportion of ambulance-assisted ED visits than those in the lowest quartile. When adjustments were made for health status, socioeconomic factors, and provider availability, these disparities were mitigated, suggesting that patients' health and economic status significantly influence the variation in ambulance utilisation [16].

A German research endeavour investigated the influence of ambulance response times on survival outcomes following out-of-hospital cardiac arrest (OHCA), utilising data from the German Resuscitation Registry spanning 2010 to 2016.

Employing logistic regression analysis, the study established a significant correlation between expedited ambulance response and elevated hospital discharge rates.

Additional determinants affecting survival outcomes included bystander resuscitation, the patient's medical history, age, circumstances of the collapse, initial heart rhythm, and the location of the collapse. Emergency medical services with faster response times were associated with more frequent initiation of resuscitation and enhanced survival rates, particularly regarding favourable neurological outcomes. This study highlights the importance of response time in determining OHCA survival, asserting its significant impact independent of the presence or absence of bystander resuscitation efforts [17]. In 2018, an Australian research project delved into the correlation between ambulance arrival metrics and the congestion of EDs in Queensland, Australia. This study entailed an analysis of data about ambulance services and EDs across 15 major hospitals, emphasising the evaluation of the Patient Off Stretcher Time (POST) target and its variations over time. The results demonstrated a relationship between the occupancy rates of EDs, the quantity of ambulances in wait, and the average POST at larger hospitals. Nonetheless, the study did not establish a direct association between POST and the duration of ED stays, a finding that may be attributed to the impact of National Emergency Access Targets [18]. A constrained body of research has been conducted on ambulance services in Hungary, with each study concentrating on a distinct aspect of healthcare.

However, these investigations have not encompassed a comprehensive examination of the activities of healthcare organisations [13].

Hospital healthcare: continuation of care

Once the patient is transported to a hospital, the focus shifts to diagnosing, treating, and monitoring their condition. Hospital healthcare involves several key components. The ED is the primary entry point for patients requiring urgent care. It is equipped to handle a wide range of emergencies, providing immediate assessment, stabilisation, and initial treatment. EDs are staffed with specialists trained in emergency medicine, capable of making rapid decisions and initiating appropriate interventions [19]. Patients with specific conditions, such as heart attacks or strokes, are often transferred to specialised care units within the hospital. These units, including intensive care units (ICU), coronary care units (CCU), and stroke units, offer advanced monitoring and treatment options tailored to the patient's needs. Following initial stabilisation, patients may be admitted to the hospital for further treatment and recovery. Inpatient care involves a multidisciplinary approach, incorporating various medical specialties to address all aspects of the patient's health. Rehabilitation services are integral to hospital care, aiding patients in regaining functionality and independence. Follow-up care ensures continuity of treatment, monitoring the patient’s progress and addressing any complications that may arise.

Theoretical models and frameworks

Several theoretical models and frameworks underpin the prehospital and hospital healthcare systems, providing structured approaches to improving patient outcomes and healthcare efficiency. The Chain of Survival is a critical concept in emergency medicine, particularly for cardiac emergencies [20]. This model outlines a sequence of actions that, when performed promptly and efficiently, can significantly improve survival rates.

The key elements of the Chain of Survival include:

- Early Recognition and Access: Immediate identification of cardiac arrest and prompt activation of emergency response systems.
- Early CPR: Cardiopulmonary resuscitation performed immediately to maintain circulation and oxygenation.
- Early Defibrillation: Timely use of defibrillators to restore normal heart rhythm, especially crucial for ventricular fibrillation and pulseless ventricular tachycardia.
- Early Advanced Care: Rapid provision of advanced life support by trained medical personnel, including intubation, medication administration, and post-resuscitation care.

These steps are interconnected, and the effectiveness of each link is crucial for the overall success of the emergency response [21].

The Trauma System Approach is designed to provide a coordinated and systematic response to traumatic injuries. It emphasises the integration of prehospital, hospital, and rehabilitative care to ensure that patients receive comprehensive treatment [22]. Key components include:

- Regionalised Trauma Care: Establishing trauma centres with varying levels of capability to handle different severities of injuries. This ensures that patients are directed to the appropriate facility based on their needs.
- Trauma Triage: Implementing protocols to quickly assess and categorise patients based on injury severity, ensuring that those with life-threatening conditions receive priority treatment.
- Trauma Teams: Specialised medical teams trained in trauma care, capable of delivering rapid and effective treatment.

- Continuous Quality Improvement: Ongoing assessment and enhancement of trauma care practices to improve patient outcomes.

This approach aims to minimise delays and optimise resource utilisation, enhancing the chances of survival and recovery for trauma patients.

Integrated care pathways (ICPs)

ICPs are structured multidisciplinary care plans that outline essential steps in the care of patients with specific clinical conditions [23]. ICPs aim to improve the quality and consistency of care by:

- Standardising Care: Ensuring that all patients receive evidence-based treatments and interventions, reducing variations in care delivery.
- Coordinating Multidisciplinary Teams: Facilitating collaboration among healthcare professionals from different disciplines, ensuring comprehensive care.
- Monitoring and Evaluating Outcomes: Regularly assessing patient outcomes and process measures to identify areas for improvement.
- Patient-Centered Care: Tailoring care plans to individual patient needs, preferences, and values.

ICPs help streamline care processes, reduce redundancy, and improve overall efficiency and patient satisfaction.**Health System Strengthening**

Health system strengthening involves enhancing the capacity of healthcare systems to deliver high-quality care [24]. This comprehensive approach includes:

- Infrastructure Development: Building and maintaining healthcare facilities equipped with modern technology and resources.

- Workforce Training and Development: Providing ongoing education and training for healthcare professionals to ensure they have the skills and knowledge needed to deliver effective care.
- Policy and Governance: Establishing policies and regulations that support effective healthcare delivery and ensure accountability.

- Intersectoral Collaboration: Promoting collaboration between different sectors, such as healthcare, education, and social services, to address the broader determinants of health.

Health system strengthening aims to create a robust and resilient healthcare system capable of responding to current and future health challenges.

Challenges and opportunities

The integration of prehospital and hospital healthcare systems presents several challenges and opportunities. Resource allocation in the integration of prehospital and hospital healthcare systems is crucial for ensuring equitable and efficient delivery of care. Effective resource allocation involves strategically distributing medical equipment, specialised personnel, and financial resources to meet the diverse needs of both prehospital and hospital settings. This includes addressing disparities in resource availability, particularly in underserved and rural areas. Utilisation of data-driven approaches and predictive analytics can optimise the allocation of resources, ensuring that patients receive timely and appropriate care.

Additionally, equitable resource distribution helps in minimising logistical challenges, reducing patient waiting times, and enhancing the overall quality of emergency medical services. By strategically allocating resources, healthcare systems can better manage patient flow, reduce overcrowding in emergency departments, and improve patient outcomes [25]. Training and education are pivotal for the effective integration of prehospital and hospital healthcare systems.

They ensure that healthcare professionals across both settings possess the necessary skills and knowledge to deliver high-quality care. Unified training programs and continuing education initiatives help bridge gaps between prehospital and hospital personnel, promoting consistency in clinical practices and protocols. Cross-training enables EMS providers to understand hospital operations better, while hospital staff gain insights into prehospital care challenges. This comprehensive approach fosters teamwork, enhances communication, and improves patient outcomes by ensuring that all healthcare providers are well-equipped to respond to emergencies efficiently and effectively. Additionally, continuous professional development and updated training on the latest medical technologies and procedures ensure that healthcare workers remain adept at utilising advanced interventions and maintaining high standards of patient care. [26]

Policy and regulations play a crucial role in the seamless integration of prehospital and hospital healthcare systems. They establish the legal and operational framework necessary for ensuring consistent, high-quality care across both settings. Effective policies facilitate standardisation of clinical protocols, data sharing, and communication between emergency medical services (EMS) and hospitals. Regulatory guidelines ensure that all healthcare providers adhere to best practices, ethical standards, and patient safety measures.

Additionally, policies that address funding, resource allocation, and training requirements support the sustainable development of integrated healthcare systems. By harmonising regulations and policies, healthcare systems can enhance coordination, improve patient outcomes, and ensure equitable access to emergency medical care [27].

Community engagement is essential for the successful integration of prehospital and hospital healthcare systems. By involving community members, healthcare providers can better understand local health needs and cultural nuances, leading to more tailored and effective emergency care services. Engagement initiatives, such as public education campaigns on emergency response and first aid, can empower individuals to act swiftly during emergencies, potentially saving lives before professional help arrives. Additionally, fostering strong relationships between healthcare providers and the community enhances trust and cooperation, ensuring that emergency medical services are responsive and accessible to all. Active community participation also aids in identifying and addressing healthcare disparities, promoting equity and improving overall public health outcomes [28].

Recent trends in prehospital and hospital healthcare

The landscape of prehospital and hospital healthcare is continuously evolving, driven by advancements in technology, changing healthcare needs, and innovative practices. Recent trends in this area reflect a shift towards more integrated, patient-centered, and efficient care delivery systems.

Telemedicine and telehealth

Telemedicine has become increasingly prevalent, especially during the COVID-19 pandemic. It allows for remote diagnosis, treatment, and consultation, reducing the need for physical hospital visits. Telehealth services enable EMS providers to connect with emergency physicians in real-time, facilitating better decision-making and patient care on-site [29].

Electronic health records (EHRs)

The adoption of EHRs has streamlined patient data management, enabling seamless sharing information between prehospital and hospital care providers. This integration improves the continuity of care, reduces errors, and enhances overall patient outcomes [30].

Mobile health applications

Mobile health applications are being used to monitor patients' health conditions, provide real-time updates to healthcare providers, and offer guidance on emergency care procedures. These applications enhance patient engagement and self-management, leading to better health outcomes with cyber-security issues [31].

Point-of-care testing (POCT)

Advances in POCT allow EMS providers to conduct diagnostic tests at the scene of an emergency. This capability enables rapid diagnosis and treatment decisions, improving patient outcomes, especially in time-sensitive conditions like myocardial infarctions and strokes [32].

Portable imaging devices

Portable ultrasound and other imaging devices are now being used in prehospital settings to assess injuries and conditions more accurately. These devices help in making informed decisions about patient transport and the level of care required [33].

Enhanced paramedic protocols

Paramedics are now trained to perform more advanced medical procedures, such as administering a broader range of medications, advanced airway management, and even some surgical interventions in extreme cases. These enhanced protocols improve the quality of care provided during the critical prehospital phase [34].

Business intelligence (BI) in EMS

BI tools are being used to analyse vast amounts of data collected from EMS operations. This analysis helps in optimising resource allocation, improving response times, and identifying areas for operational improvement. Data-driven decision-making ensures that EMS services are both efficient and effective [35].

Predictive analytics

Predictive analytics in healthcare involve using historical data to forecast future events, such as predicting high-demand periods for EMS or identifying populations at higher risk for certain emergencies. This proactive approach allows for better preparedness and resource planning [36].

Geospatial information systems (GIS)

GIS technology is being utilised to map emergency incidents, analyse spatial patterns, and optimise the deployment of EMS units. This technology enhances the ability to respond to emergencies quickly and efficiently, especially in urban and rural settings [37].

Community paramedicine

Community paramedicine programs extend the role of EMS providers beyond emergency response to include preventive care, chronic disease management, and health education. These programs aim to reduce hospital readmissions, improve patient outcomes, and enhance community health [38].

Patient engagement and education

There is a growing emphasis on involving patients in their own care. Educational programs and resources are provided to patients and their families to help them understand their conditions, the importance of early intervention, and how to access emergency services effectively [39].

Standardisation of care protocols

Efforts are being made to standardise care protocols across EMS and hospital settings to ensure consistency and quality of care. Standardised protocols reduce variability in treatment and improve patient outcomes [40].

Legislative support for EMS

Governments are increasingly recognising the importance of EMS in the healthcare system and are enacting laws and regulations to support its development. This includes funding for advanced training, infrastructure improvements, and research initiatives.

Public health integration

EMS services are being integrated into broader public health strategies to address community health issues comprehensively. This integration helps in early detection of public health threats, efficient management of health emergencies, and improved overall public health outcomes.

I.4. Structure of different emergency care systems

Emergency care systems worldwide are designed to provide immediate medical attention to individuals suffering from acute illnesses or injuries. These systems vary significantly between countries, shaped by historical, cultural, and systemic factors. Two primary models dominate the global landscape: the Anglo-Saxon and Franco-German systems [41].

Anglo-Saxon model

The Anglo-Saxon model, prevalent in countries such as the United States, the United Kingdom, Canada, and Australia, is characterised by a decentralised approach to emergency care. EMSs operate independently within regions, often governed by local authorities or private organisations. Hospitals and EDs are integral parts of the healthcare system, often providing a broad range of services. Paramedics and EMTs are trained to perform advanced life-saving procedures on-site, but prehospital care focuses on stabilising patients and transporting them to specialised care centres when necessary. EDs serve as the primary access point for emergency care, staffed with specialists trained in emergency medicine. Triage systems prioritise patients based on the severity of their conditions, ensuring timely treatment. Public education and involvement are significant, with campaigns to promote awareness of emergency services and first aid training.

Franco-German model

The Franco-German model, used in countries like France, Germany, and several other European nations, is more centralised and integrates emergency services with the overall healthcare system.

EMS are typically integrated into the national healthcare system, ensuring uniform standards and protocols. A central dispatch system coordinates emergency responses, ensuring efficient resource allocation. Emergency physicians often respond to the scene, providing advanced medical care before hospital transport. MICUs are common, equipped with advanced medical equipment and staffed by physicians and nurses. Hospitals are directly involved in emergency response, with specialised units for acute care. The focus is on providing comprehensive care from the stage to the hospital, minimising the need for further patient transfers.

Hungarian emergency care system

Hungary's emergency care system is unique, incorporating elements from both the Anglo-Saxon and Franco-German models. The NAS plays a central role, and its structure and functioning are shaped by Hungarian regulations and healthcare policies. Hungarian emergency care is regulated by the Ministry of Interior, ensuring compliance with the government’s national healthcare policies. Regular audits and evaluations are conducted to maintain the quality of care provided by both the NAS and hospital EDs. The NAS and hospital EDs are closely integrated, ensuring seamless patient transfer and continuity of care.

Prehospital interventions aim to stabilise patients before transport, reducing the burden on EDs and improving outcomes. Regular updates to SOPs ensure that the NAS maintains high standards of care, and these procedures are aligned with hospital protocols. EDs are the primary access points for emergency medical care in Hungary.

They are located within hospitals and are staffed by specialists trained in emergency medicine. Triage systems in EDs prioritise patients based on the severity of their condition, ensuring that those in critical need receive immediate attention. Upon arrival at the hospital, patients are assessed in the ED or, if necessary, directly arrive at specialised care units such as ICUs, CCUs, or stroke units. These units are equipped with advanced medical technology and staffed by multidisciplinary teams to provide comprehensive care for acute conditions. Hungary has a network of specialised centres, including 16 PCI centres and 39 stroke centres, six of which are equipped for mechanical thrombectomy. These centres provide advanced treatment for acute conditions such as myocardial infarction and stroke, working closely with the NAS to ensure timely intervention. After stabilisation and initial treatment, patients may be admitted to the hospital for further care or transferred to rehabilitation facilities for recovery. The continuity of care from prehospital to hospital and post-hospital phases is crucial for improving patient outcomes and reducing mortality rates. The overall Hungarian healthcare system faces challenges, but as emergency care has one of the most patient flows it’s even more deprived. One of the significant challenges facing Hungary's emergency care system is the shortage of healthcare professionals, including paramedics and emergency physicians.

This shortage affects various aspects of the emergency care continuum, from prehospital services provided by the NAS to hospital-based emergency departments. The implications of this shortage are profound, impacting the quality, efficiency, and accessibility of emergency medical services across the country. The cause of the shortage is multifactorial. A significant portion of Hungary's healthcare workforce is approaching retirement age, leading to a decline in the number of active healthcare professionals.

The aging workforce exacerbates the shortage as experienced personnel leave the field without adequate replacement. Many Hungarian healthcare professionals seek employment opportunities abroad, attracted by better working conditions, higher salaries, and career advancement prospects. This emigration trend contributes to the domestic shortage of qualified personnel. The number of new graduates from medical and paramedical training programs does not meet the growing demand for healthcare services. Limited capacity in training institutions and insufficient incentives for pursuing careers in emergency medicine contribute to this gap. Challenging working conditions, including long hours, high stress, and inadequate compensation, deter individuals from entering or remaining in the emergency care profession. The demanding nature of the job, combined with insufficient support, leads to burnout and attrition. The shortage of healthcare professionals directly impacts the quality of patient care. Delays in response times, prolonged waiting periods in EDs, and reduced availability of specialised care are common consequences. Patients in rural and remote areas are particularly affected, as the shortage is more pronounced in these regions, leading to disparities in access to emergency medical services.

Healthcare professionals currently in the system face increased workloads, leading to higher levels of stress and burnout. This not only affects their well-being but also the quality of care they provide. Overburdened staff may experience decreased job satisfaction, further exacerbating retention issues and contributing to the cycle of workforce shortages. The shortage creates operational challenges for the NAS and hospital EDs, including difficulties in maintaining adequate staffing levels, managing shift rotations, and ensuring coverage during peak times.

Resource constraints limit the ability to implement innovative care models and improvements, hindering efforts to enhance the efficiency and effectiveness of emergency care services. Strategies to address this issue include HR developments as in, improving working conditions and offering competitive salaries, structural changes like new NAS stations and more air ambulance with better communication and change of focus in education policies both in the medical doctor and healthcare professional curriculum. These development plans were already formulated by researchers in 2006, but some have still not been implemented [42].

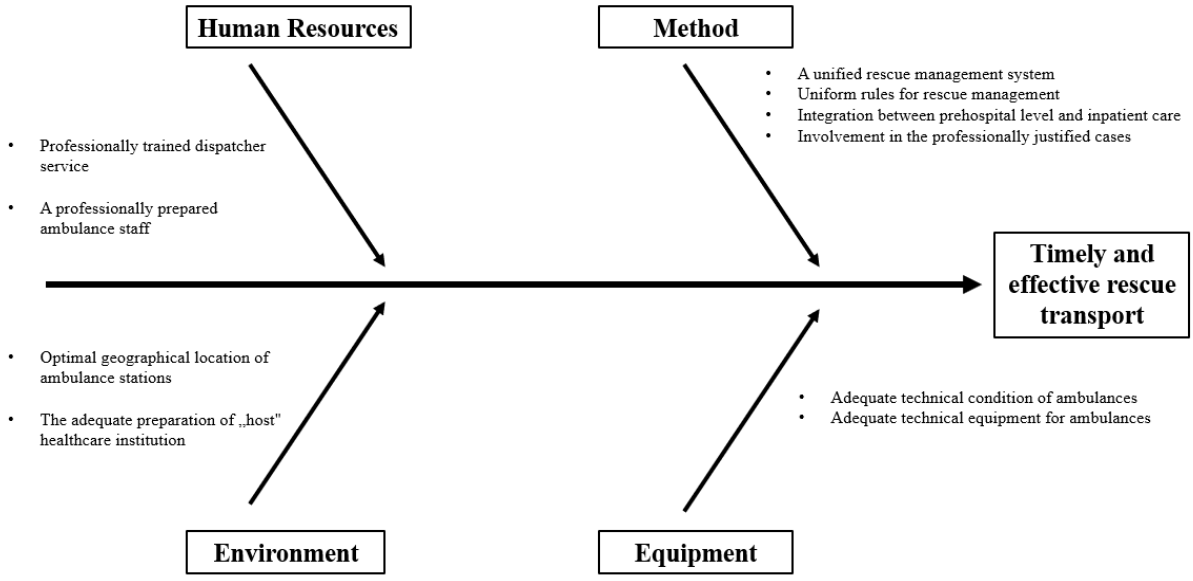

Figure 3.: Conceptual diagram of the determining factors in the time of the rescue, and the optimisation of the time factor

I.5. Current national laws and regulations

Hungarian regulatory environment

The regulatory environment of Hungarian healthcare is a comprehensive and coordinated legal and regulatory system designed to ensure high-quality patient care, promote access to health services, and efficiently manage the healthcare system. This legal framework is based on the Fundamental Law (Constitution), which, under Article XX, states that "every individual has the right to maintain their physical and mental health." This fundamental legal principle guides the healthcare regulatory environment, aiming to protect health, improve the quality of healthcare, promote equality, protect patients' fundamental rights, establish professional standards, define institutional frameworks and human resources, and harmonise individual and community healthcare tasks. Act CLIV of 1997 on Health encompasses fundamental rules for all professionals participating in the healthcare system. The act aims to define the rights and obligations of all participants in the healthcare system, ensuring comprehensive and unified regulation of healthcare services. The provisions are "sector-neutral," meaning they apply to all healthcare activities and services regardless of the provider and financing form, and they generally establish the rights and obligations of the parties involved. The Hungarian healthcare regulatory system also includes various government and ministerial decrees and municipal regulations affecting different areas of healthcare services. These regulations detail the financing systems, the operation of healthcare institutions, professional standards, the training and legal status of healthcare workers, and the quality control of healthcare services.

Beyond laws and decrees, numerous lower-level regulations exist, such as guidelines from various healthcare professional societies, contributing to maintaining and improving the healthcare system's quality. These lower-level regulations allow the healthcare system to flexibly adapt to changing circumstances and professional developments, while the legal framework ensures consistency and adherence to unified guidelines.

Act CLIV of 1997 on health

This law regulates the healthcare delivery system, the provision of health services, the definition of patients' rights and obligations, and the legal status and tasks of healthcare workers. It forms the basis of the Hungarian healthcare regulatory framework, primarily aiming to regulate the activities, rights, and obligations of various healthcare actors. The importance of the act lies in providing a detailed framework for the operation of the healthcare system, including the organisational structure of healthcare institutions, operational norms, and the quality of healthcare services. It details patients' rights and obligations, ensuring their protection and information, and fair treatment during healthcare provision. The regulations governing healthcare workers' rights and obligations are crucial, ensuring adherence to professional standards, ethical norms, and workplace safety. The act also regulates the training, continuing education, and professional development of healthcare workers, promoting continuous improvement in professional competence. The act aligns with international norms and guidelines, ensuring the Hungarian healthcare system's consistency with international healthcare standards and practices.

Thus, the law contributes to maintaining high-quality healthcare, the efficient and equitable operation of health services, and the transparency and accountability of the healthcare system.

Act LXXX of 1997 on health insurance

This law sets out the legal foundations and frameworks of the Hungarian health insurance system, including public and private health insurance systems, social security benefits, and the regulation of healthcare service financing. This legal framework is crucial for ensuring the efficient and equitable operation of the health insurance system, which is key to accessing healthcare services for the population. The law details the role and operation of public health insurance, which is mandatory and funded through the state budget and social security contributions. Public insurance can cover a broad spectrum of healthcare services, including preventive care, acute and chronic patient care, and rehabilitation services. Social security benefits are part of the health insurance system, providing cash and in-kind benefits related to illness, incapacity, childcare, and other social risks. These benefits are based on social security contributions paid by employees and employers and operate as part of the social security system. The regulation of healthcare service financing is another key element of the law, encompassing the methods of financing healthcare services, financing healthcare providers, and the rules of cost-sharing and reimbursement systems. This regulation ensures the sustainability of the healthcare system, the efficient allocation of financial resources, and promotes high-quality and equal access to healthcare services.

Act XCVIII of 2004 on the price of pharmaceuticals, medical devices, and medical services and on the pharmaceutical support

This act, part of the Hungarian healthcare regulatory framework, encompasses the regulation of pharmaceutical pricing, the pricing of medical devices, and the pharmaceutical support system.

This law is of fundamental importance in the healthcare delivery system, as it defines the principles of pricing for pharmaceuticals and medical devices and the operation and structure of the pharmaceutical support system. The aim is to ensure that the pharmaceutical and medical device markets operate in a regulated and transparent manner, ensuring the availability of high-quality and affordable medicines and medical devices for patients. According to the act, the process of pricing pharmaceuticals and medical devices is controlled by relevant regulatory authorities, ensuring that prices comply with market conditions while considering public health and social factors. The regulation of the pharmaceutical support system is another crucial aspect of the law, determining the conditions under which pharmaceuticals support reach patients. This includes the criteria for pharmaceutical support, the categories of supported medicines, and the extent and method of support. The system aims to make socially and health-important pharmaceuticals widely available to the population while considering state budget constraints and the sustainability of healthcare delivery. The regulated areas also include the regulations related to marketing, quality control, and safety of pharmaceuticals. These regulations ensure that the pharmaceuticals available on the market comply with international and domestic quality and safety standards and promote the development and introduction of innovative drugs and therapeutic procedures. Such regulations contribute to improving efficiency, safety, and quality of care provided to patients.

Act LXXXIII of 1998 on the coverage of publicly financed health services and the related copayments

This act provides the fundamental framework for the operation of the state-funded healthcare services system, including the types of services, their availability, and the determination of copayments. The aim of the act is to define which healthcare services fall within the scope of state funding, thereby guaranteeing that basic healthcare services are accessible to the population. The act details the copayment system. The determination of copayments is crucial to ensure that healthcare services operate sustainably while guaranteeing access to basic healthcare for all citizens. The act thus regulates the copayments associated with various healthcare services, which can vary based on the type of service, the patient's condition, and other factors. Furthermore, the act specifies the conditions under which certain patients may be exempt from various copayments, such as low income, chronic illness, or other social factors. This ensures the possibility of equal access to healthcare services, particularly for disadvantaged groups in society.

Ministerial decree 5/2006 on emergency services

This decree, as an important part of the Hungarian healthcare regulatory framework, regulates the activities of emergency services. The decree contains fundamental requirements for the organisational structure of emergency services, the requirements for performing emergency tasks, the training and continuing education of emergency personnel, and the use of emergency equipment and supplies. The primary aim of the decree is to ensure effective, rapid, and professional emergency care for the Hungarian population and to support the continuous development and modernisation of emergency activities.

The decree regulates the structure of emergency services in detail, including the organisational structure of emergency services, the operating principles of different types of emergency units, and the territorial distribution of emergency services. The provisions of the decree ensure that emergency services are available in all areas and can respond quickly and effectively to emergency situations. The training and continuing education of emergency personnel is another key area of the decree. The decree prescribes the requirements for basic, specialised, and continuing education for emergency personnel, ensuring that emergency service workers are always up to date with new rescue techniques and procedures and comply with the highest professional and ethical standards. The regulations on the use of emergency equipment and supplies are also an important part of the decree. These provisions include the standards, use, and maintenance of medical equipment, ambulances, and other rescue tools, ensuring that emergency services have all the necessary equipment to perform effective and safe rescue operations.

Act C of 2020 on the service status of healthcare workers

This act is a significant piece of legislation that brought substantial changes to the operation of the Hungarian healthcare system, particularly concerning the employment status of healthcare workers. The aim of the act is to establish new legal frameworks for healthcare sector workers, thereby promoting the more efficient operation of the sector, better working conditions for workers, and higher-quality patient care. The act introduced a new form of service status for healthcare workers, which represents a significant departure from the previous employment law system.

The essence of the new service status is that healthcare workers, as a kind of transition between civil servants and law enforcement personnel, receive a special employment status that transforms the payment and benefit system, as well as several other elements of employment. The act regulates the working conditions of healthcare workers in detail, including working hours, rest periods, overtime rules, and the system of holidays. Additionally, the act states that healthcare workers must be provided with continuous training and further training opportunities, thereby promoting their professional development and high-quality patient care. The act also addresses disciplinary and ethical norms and the legal remedies available to healthcare workers.

I.6. Hungarian national ambulance service

The NAS is unique on several fronts, such as its age, size, number of staff, and consistency. It was established on May 10, 1948, but the need for assistance was recognised sooner at the beginning of the 19th century [43]. The legal predecessor of the NAS - the employees of the Budapest Voluntary Rescue Association (Budapesti Önkéntes Mentő Egyesület - BÖME) - took up their first service on May 10, 1887, as the 3rd in the world in terms of organised rescue (1865 USA Ohio, 1867 UK London). In these early days, the "patient to hospital" model prevailed, so without trying to stabilise the condition, they sought only to deliver the patients to the place of care as soon as possible. However, of course, this model could not work effectively without the effort to stabilise the patient during transport. The "hospital to patient" model soon became established in Europe and was sought at an early stage. Apply as many lifesaving and state-stabilising solutions as possible on-site.

The National Ambulance Service in Hungary, entirely funded by the government, is responsible for all ambulance deliveries. The NAS plays a crucial role in numerous medical emergencies, with particular emphasis on stroke and acute myocardial infarction (AMI) in the context of amenable mortality. Over recent decades, the NAS has been actively engaged in informing and educating both the public and medical practitioners in Hungary about the importance of immediate ambulance summoning in cases of suspected acute coronary syndrome or stroke, aiming to reduce pre-hospital delays in reperfusion therapy.

The evaluation of the performance of Hungary's ambulance service offers critical insights for health policy decision-makers. It presents a unique model in the international context of a singular, nationally level provider offering comprehensive ambulance coverage, entirely publicly funded and characterised by uniform approaches and procedures [43].

Potential errors in amenable mortality may arise in pre-hospital, institutional, and acute care settings. However, the ambulance service's performance is particularly pivotal regarding time factors and care quality [44]. Apart from these aspects, it is also imperative for the service provider to diligently work towards minimising geographic inequalities. Achieving this goal necessitates aligning the rate of ambulance deliveries, which mirrors the accessibility of services provided by the NAS, with the healthcare needs of the broader population. The significance of prehospital care to amenable mortality cannot be overstated, as it plays a critical role in reducing preventable deaths and improving patient outcomes. As described earlier, amenable mortality refers to deaths that could be avoided through timely and effective healthcare interventions, including optimal prehospital care [5,6]. In this context, prehospital care encompasses the range of medical services and interventions provided to patients before they arrive at a healthcare facility, typically administered by EMSs and ambulance personnel.

A key component of prehospital care is the rapid response to medical emergencies, ensuring patients receive appropriate treatment as early as possible [45]. Early intervention is crucial in many life-threatening situations, such as acute myocardial infarction, stroke, and severe trauma, where timely care can significantly improve survival rates and reduce long-term morbidity [7,8].

Furthermore, prehospital care providers are trained to stabilise patients, manage pain, and initiate critical interventions, such as advanced airway management and cardiopulmonary resuscitation, which can be lifesaving during the crucial period between the onset of a medical emergency and arrival at a healthcare facility [44,45].

In addition to providing immediate medical care, prehospital care providers make vital patient triage, transport, and destination decisions. Precise triage protocols guarantee the prioritisation of patients according to the criticality of their medical condition and the immediacy required for medical intervention [46]. This process enables the efficient allocation of resources and reduces the likelihood of overcrowded emergency departments, thereby promoting overall healthcare system efficiency and effectiveness [47]. Furthermore, prehospital care providers are tasked with determining the most appropriate destination for patients, such as specialised stroke, trauma, or cardiac care centres, which can significantly impact patient outcomes and amenable mortality rates [48]. Prehospital care also plays an essential role in promoting health equity by addressing disparities in access to healthcare services. In rural and underserved areas, where healthcare facilities may be scarce or distant, prehospital care can be vital to ensure that patients receive timely and appropriate care [13,14].Additionally, prehospital care providers can help identify and address social determinants of health that contribute to amenable mortality, such as poverty, lack of education, and inadequate housing, by connecting patients with relevant resources and support services [16,17]. In conclusion, prehospital care is paramount in connection with amenable mortality, as it reduces preventable deaths and improves patient outcomes. The timely provision of appropriate interventions, accurate triage, and optimal transport decisions contribute to the effectiveness of prehospital care in mitigating amenable mortality rates. Moreover, prehospital care is pivotal in mitigating health disparities and fostering equity by providing healthcare access to vulnerable groups. Sustained investment in and backing prehospital care infrastructures are imperative in persistent endeavour to reduce amenable mortality and augment public health standards.

II. Objectives of our research

Our study aimed to investigate the operational efficacy of the National Ambulance Service (NAS) and explore the association between territorial attributes pertinent to rescue operations, utilisation of capacities, and regional disparities in the amenable mortality rates among the Hungarian population. Furthermore, the research sought to uncover potential geographical disparities in ambulance rescue activities before and during the COVID-19 pandemic. The researches examined the years 2018 as before COVID-19 and 2019-2021 as during the pandemic. The findings from this investigation are intended to aid policymakers in pinpointing regions within the country that require targeted interventions to address disparities in healthcare delivery. Every healthcare provider has a vital role in the well-being of society, but our research focused on the ambulance service for several reasons. First, the NAS is the country's most significant healthcare provider and employer; with uniform guidelines, many patients get treatment from the NAS and are treated equally. Also, the data from the NAS is available owing to the installation of the intelligent onboard terminal, which is a digital way to record patient data. Finally, the most critical diseases from the point of amenable mortality, stroke and AMI, are closely related to NAS activities because both conditions can be improved with the proper quality of care started at the right time.

III. Materials and methods

The studies received ethical approval from the Hungarian Medical Research Council's Scientific Research and Ethics Committee, with authorisation numbers ETT-TUKEB 41880-2/2019/EKU and IV/5553-2/2020/EKU for the pre-and during-COVID periods, respectively. Focusing on amenable mortality among adults aged 15–64, we excluded older populations and examined deaths concerning health services and ambulance rescue data. Data sources included the Hungarian Central Statistical Office and the National Ambulance Service, covering acute myocardial infarction, hemorrhagic and ischemic strokes. The data from NAS were selected based on a guideline diagnosis recorded on the “case sheet” used by the service. Since its introduction in 1976, avoidable mortality has experienced considerable evolution in its substance and nomenclature, notably including an adjustment in the upper age boundary from 64 to 74 years. This modification in the age limit is substantiated by the consistent rise in life expectancy at birth and the observation that more favourable outcomes are attainable in older age groups through advanced health interventions [48,49]. We observed significant variations in life expectancy across Europe, with the Hungarian population lagging almost three years behind the European average in 2015 and a marked gender disparity in life expectancy within Hungary itself [50]. The gap in life expectancy between men and women in Hungary is notable. In 2015, this difference was approximately 8.8 years. Although there has been some improvement, the gap remained significant at 6.47 years in 2019, with male life expectancy at 72.86 years and female life expectancy at 79.33 years [51,52]. Additionally, Hungary's population is characterised by markedly poor health outcomes, particularly in the "early death stage of life" within the 25–64 age group [50, 53, 54].

This situation necessitates a focused analysis of deaths associated with health services in the 15–64 age demographic. For this purpose, the lower age limit was adjusted from 18 to 15 years, facilitating the categorisation of age distributions into consistent five-year segments. The second part of the research focuses on acute myocardial infarction (AMI; ICD10: I21, I22), hemorrhagic stroke (ICD10: I60, I61, I62), and ischemic stroke (ICD10: I63, I64), as these conditions are most directly assessable in ambulance services with minimal external influencing factors and during the COVID-19 pandemic; overall non-COVID-19 related ambulance deliveries, COVID-19 screenings done by the ambulance service, and COVID-19 related ambulance deliveries. These diseases are critical for timely intervention by ambulance services. The research utilised national data on ambulance rescue operations and mortality rates, organised at the county level according to the Nomenclature of Territorial Units for Statistics at level 3 (NUTS 3). To address these disparities, our analysis incorporated pre-COVID-19 and COVID-19-era data, spanning January 2019 to December 2021. This period was chosen due to the implementation of a uniform data recording method by the Hungarian National Ambulance Service in late 2018 and because of the new challenges NAS faced during the pandemic. The initial datasets procured comprised unfiltered raw indicators, which presented a challenge for comparative analysis due to varying age and gender distributions potentially skewing the results. Indirect standardisation was employed, using the national frequencies of ambulance rescues and mortality as reference points. This approach enabled the calculation of mortality rates for each county, thereby facilitating an examination of territorial disparities within the nation.

The analysis involved calculating the standardised mortality for the specified diseases and the standardised ambulance rescue rates for corresponding cases to assess inter-county discrepancies. The standardised mortalities were expressed as Standardized Mortality Ratios (SMR) accompanied by 95% confidence intervals. All computations were conducted using Microsoft Excel. Our comprehensive data sets included various non-COVID-19, and COVID-19-related ambulance activities stratified by age and gender. To elucidate the temporal alignment of screenings and deliveries with the four COVID-19 waves in Hungary, we determined the onset and conclusion of each wave. The demarcation of COVID-19 waves is a subject of ongoing scholarly debate [55,56]. However, for our analysis, we adopted a methodology focusing on the virus's reproduction rate (R). According to this criterion, except for the initial case reported in Hungary, the commencement of a COVID-19 wave was identified when the R-value consistently exceeded one over two weeks. Conversely, the conclusion of a wave was designated two weeks before the R-value subsequently surpassed one again. Data about the R-values during the COVID-19 pandemic in Hungary were sourced from the Our World in Data website [57]. Given that the earliest available data was from March 22nd, 2020, it was deemed appropriate to consider the first confirmed case of COVID-19 in Hungary as the start of the initial wave. We employed statistical techniques like Pearson's chi-squared test, Student's t-test, and the Shapiro-Wilk test for our analysis. Additionally, we calculated ratios, means, standard deviations, and other descriptive statistics using Microsoft Excel for data visualisation and STATA v13 for comparative analyses. This approach allowed us to map territorial inequalities and assess the impact of COVID-19 on health service-related deaths and ambulance activities in Hungary.

Contributions of the author of the thesis

The author of this thesis and his supervisor, Klára Bíró, in collaboration with Attila Nagy and Viktor Dombrádi, were instrumental in developing the methodology and performing the formal analysis. The assembly of resources and curation of data were managed by Gábor Csató, Csilla Nagy, Attila Juhász and György Pápai. The thesis author was responsible for preparing databases pertinent to all statistical analyses conducted in the study and it was his job to find the relevant literatures. The writing of both papers, which are the basis of this thesis, was a joint effort by the author of this thesis, Klára Bíró, Attila Nagy, and Viktor Dombrádi, while the author of the thesis and Viktor Dombrádi also took on the role of visualising the data.

IV. Results

IV.1. Before the COVID-19 pandemic

In 2018, the Hungarian population between the ages of 15 and 65 numbered 6,729,449. Among this demographic, 29,154 deaths occurred, and the Hungarian National Ambulance Service (NAS) conducted 369,672 emergency deliveries (Table 2). In the tables we marked the counties with abbreviations to ensure readability as Bács-Kiskun: BK, Baranya: BA, Békés:BE, Borsod-Abaúj-Zemplén: BAZ, Budapest (capital): BP, Csongrád: CS, Fejér: FE, Győr-Moson-Sopron: GMS, Hajdú-Bihar: HB, Heves: HE, Jász-Nagykun-Szolnok: JNS, Komárom-Esztergom: KE, Nógrád: NO, Pest: PE, Somogy: SO, Szabolcs-Szatmár-Bereg: SSB, Tolna: TO, Vas: VA, Veszprém: VE and Zala: ZA.

Table 2. Percentage of the overall Hungarian population, mortality and ambulance deliveries between the ages 15–64 years in 2018 at the county level. Source: Own elaboration.

County	Population between 15-64 years (N)			All mortality for 15-64 years old (N)			All ambulance transports for 15-64 years old (N)		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
BK	175180	178633	353812	506	1125	1631	8068	10651	18719
BA	130845	130424	261269	434	785	1219	7839	9719	17558
BE	117789	121209	238998	408	801	1209	7433	9372	16805
BAZ	228359	233711	462069	818	1667	2485	14024	16131	30155
BP	576657	542221	1118878	1449	2474	3923	20652	28689	49341
CS	139093	139851	278943	441	755	1196	5250	7077	12327
FE	143405	147956	291361	394	925	1319	6639	9566	16205
GMS	152064	154988	307052	389	802	1191	6932	10777	17709
HB	184992	187953	372945	460	950	1410	12398	14496	26894
HE	100689	100813	201501	353	663	1016	6758	8165	14923
JNS	126828	130746	257574	461	919	1380	8170	9376	17546
KE	104583	106464	211047	339	619	958	4409	5936	10345
NO	65266	67612	132878	203	529	732	3316	4362	7678
PE	431330	435776	867105	1165	2160	3325	9906	12176	22082
SO	106242	107661	213902	336	695	1031	6450	8018	14468
SSB	199303	206502	405805	590	1235	1825	16045	19631	35676
TO	76193	77828	154021	222	441	663	3686	4872	8558
VA	85518	86978	172495	219	586	805	4281	6556	10837
VE	117564	121262	238825	331	707	1038	5370	7706	13076
ZA	93942	95032	188974	252	556	808	3788	4982	8770
Total	3355836	3355836	6729449	9770	19394	29164	161414	208258	369672

Table 3 presents the data on ambulance deliveries associated with AMI concerning AMI mortality rates. The findings reveal notable discrepancies from the national average in AMI mortality rates and AMI-related ambulance deliveries across four Hungarian counties. For example, Baranya and Hajdú-Bihar counties demonstrated significantly lower AMI mortality rates (0.55 [0.36–0.74] and 0.64 [0.47–0.74], respectively), accompanied by markedly lower AMI-related ambulance deliveries in these areas. In contrast, Borsod-Abaúj-Zemplén and Jász-Nagykun-Szolnok counties exhibited considerably higher AMI mortality rates (1.28 [1.06–1.51] and 1.32 [1.02–1.61], respectively). Furthermore, these counties also experienced substantially elevated AMI-related ambulance deliveries compared to the national average.

Table 3. AMI mortality and AMI-related ambulance deliveries in Hungary, 2018. Source: Own elaboration.

County	Mortality			Ambulance transports			Adjusted mortality rate /
	AMI mortality (N)	Percentage	Adjusted	AMI transports (N)	Percentage	Adjusted	
BK	67	4.1	0.81	175	0.9	0.83	0.98
BA	33	2.7	0.54	136	0.8	0.68	0.79
BE	54	4.5	0.88	182	1.1	0.94	0.93
BAZ	128	5.2	1.02	453	1.5	1.37	0.74
BP	236	6.0	1.20	572	1.2	1.04	1.15
CS	54	4.5	0.89	126	1.0	0.91	0.98
FE	64	4.9	0.96	327	2.0	1.79	0.54
GMS	55	4.6	0.91	132	0.7	0.66	1.38
HB	51	3.6	0.72	192	0.7	0.65	1.10
HE	60	5.9	1.17	242	1.6	1.44	0.81
JNS	76	5.5	1.09	195	1.1	0.99	1.09
KE	50	5.2	1.03	120	1.2	1.03	1.00
NO	35	4.8	0.94	123	1.6	1.40	0.67
PE	195	5.9	1.16	181	0.8	0.75	1.55
SO	49	4.8	0.94	106	0.7	0.63	1.48
SSB	101	5.5	1.10	382	1.1	1.00	1.10
TO	36	5.4	1.07	168	2.0	1.70	0.63
VA	42	5.2	1.03	63	0.6	0.50	2.04
VE	46	4.4	0.87	192	1.5	1.27	0.69
ZA	42	5.2	1.02	71	0.8	0.69	1.49

The analysis of hemorrhagic stroke-related ambulance deliveries concerning hemorrhagic stroke mortality rates demonstrates significant deviations from the national average for mortality rates and ambulance deliveries in five Hungarian counties (Table 4). Notably, lower hemorrhagic stroke mortality rates were identified in the capital, Budapest (0.67 [0.52–0.82]), Pest County (0.76 [0.58–0.95]), and Vas County (0.49 [0.17–0.81]). In these regions, hemorrhagic stroke-related ambulance deliveries were also significantly reduced. Conversely, Szabolcs-Szatmár-Bereg county experienced significantly higher hemorrhagic stroke mortality rates (1.41 [1.04–1.78]), accompanied by a substantial increase in hemorrhagic stroke-related ambulance deliveries. Borsod-Abaúj-Zemplén county, on the other hand, exhibited a significantly elevated hemorrhagic stroke mortality rate (1.73 [1.35–2.11]) while simultaneously displaying a markedly lower rate of hemorrhagic stroke-related ambulance deliveries (0.58 [0.40–0.76]).

Table 4. Hemorrhagic stroke mortality and hemorrhagic stroke-related ambulance deliveries in Hungary, 2018. Source: Own elaboration.

County	Mortality			Ambulance transports			Adjusted mortality rate / adjusted ambulance transport rates
	Hemorrhagic stroke mortality (N)	Percentage	Adjusted rates	Hemorrhagic stroke transports (N)	Percentage (%)	Adjusted rates	
BK	45	2.8	1.18	48	0.3	0.98	1.21
BA	21	1.7	0.74	172	1.0	3.71	0.20
BE	34	2.8	1.21	51	0.3	1.15	1.05
BAZ	80	3.2	1.38	38	0.1	0.49	2.80
BP	73	1.9	0.80	82	0.2	0.63	1.26
CS	35	2.9	1.25	31	0.3	0.96	1.30
FE	29	2.2	0.94	32	0.2	0.75	1.25
GMS	25	2.1	0.90	45	0.3	0.97	0.93
HB	33	2.3	1.00	41	0.2	0.59	1.69
HE	24	2.4	1.01	56	0.4	1.43	0.71
JNS	24	1.7	0.75	62	0.4	1.36	0.55
KE	19	2.0	0.85	17	0.2	0.63	1.35
NO	13	1.8	0.76	20	0.3	0.99	0.77
PE	64	1.9	0.82	20	0.1	0.35	2.34
SO	30	2.9	1.25	49	0.3	1.28	0.98
SSB	55	3.0	1.29	95	0.3	1.05	1.22
TO	11	1.7	0.71	20	0.2	0.88	0.81
VA	9	1.1	0.48	17	0.2	0.59	0.81
VE	31	3.0	1.28	41	0.3	1.18	1.08
ZA	26	3.2	1.38	29	0.3	1.23	1.13

Table 5 overviews the relative values of ischemic stroke mortality rates and ischemic stroke-related ambulance deliveries. The data indicate significant disparities from the national average in ischemic stroke mortality rates and ischemic stroke-related ambulance deliveries across eleven Hungarian counties. Remarkably lower ischemic stroke mortality rates were observed in Budapest (0.84 [0.81–0.86]), Pest County (0.93 [0.90–0.97]), and Zala County (0.90 [0.84–0.96]). Correspondingly, these regions also experienced significantly reduced ischemic stroke-related ambulance deliveries. In contrast, significantly higher ischemic stroke mortality rates were detected in Békés (1.11 [1.04–1.11]), Borsod-Abaúj-Zemplén (1.26 [1.21–1.31]), Heves (1.13 [1.06–1.20]), Jász-Nagykun-Szolnok (1.21 [1.15–1.28]), Nógrád (1.21 [1.12–1.29]), and Szabolcs-Szatmár-Bereg (1.10 [1.05–1.15]) counties. Moreover, these counties experienced notably higher ischemic stroke-related ambulance deliveries than the national average.

Table 5. Ischemic stroke mortality and ischemic stroke-related ambulance deliveries in Hungary, 2018. Source: Own elaboration.

County	Mortality			Ambulance transports			Adjusted mortality rate / adjusted ambulance transport rates
	Ischemic stroke mortality (N)	Percentage (%)	Adjusted rates	Ischemic stroke transports (N)	Percentage (%)	Adjusted rates	
BK	34	2.1	0.93	418	2.2	0.97	0.96
BA	19	1.6	0.69	447	2.5	1.09	0.64
BE	29	2.4	1.06	364	2.2	0.92	1.15
BAZ	63	2.5	1.14	719	2.4	1.07	1.06
BP	82	2.1	0.95	1016	2.1	0.91	1.04
CS	29	2.4	1.09	157	1.3	0.56	1.95
FE	31	2.4	1.05	397	2.4	1.07	0.98
GMS	21	1.8	0.79	361	2.0	0.90	0.88
HB	21	1.5	0.67	344	1.3	0.58	1.16
HE	23	2.3	1.01	362	2.4	1.05	0.96
JNS	17	1.2	0.55	366	2.1	0.91	0.60
KE	24	2.5	1.12	353	3.4	1.50	0.75
NO	20	2.7	1.21	246	3.2	1.37	0.88
PE	67	2.0	0.92	578	2.6	1.19	0.77
SO	20	1.9	0.85	426	2.9	1.24	0.69
SSB	47	2.6	1.17	740	2.1	0.96	1.22
TO	13	2.0	0.87	196	2.3	0.97	0.89
VA	19	2.4	1.05	232	2.1	0.91	1.15
VE	35	3.4	1.50	392	3.0	1.28	1.17
ZA	36	4.5	1.96	299	3.4	1.41	1.39

IV.2. During the COVID-19 pandemic

From January 2019 to December 2021, the Hungarian National Ambulance Service (NAS) conducted 2,798,348 emergency deliveries for patients aged 15, including 190,734 COVID-19 cases. Additionally, NAS performed 1,557,388 COVID-19 screenings. The distribution of these activities, based on age and gender, is illustrated in Tables 6 and 7. A comparison of the distribution of gender and age concerning COVID-19 screenings and COVID-19-related ambulance deliveries revealed significant differences between 2020 and 2021 ($p < 0.001$).

Table 6. Number and distribution of various non-COVID-19 related deliveries by the NAS between 2019 and 2021 Source: Own elaboration.

	2019		2020		2021		2019/2020	2019/2021	2020/2021
	N	%	N	%	N	%	P-value	P-value	P-value
Acute myocardial infarction (ICD10: I21, I22)									
male	1,787	56.4%	2,024	56.9%	2,030	57.4%	0.531	0.553	0.600
female	1,074	33.8%	1,232	34.6%	1,203	34.0%			
missing	312	9.8%	302	8.5%	304	8.6%			
Age									
15-65	1,611	50.8%	1,767	49.7%	1,798	50.9%	0.366	0.968	0.332
65+	1,535	48.3%	1,760	49.5%	1,710	48.3%			
missing	27	0.9%	31	0.8%	29	0.8%			
Haemorrhagic stroke (ICD10: I60, I61, I62)									
male	155	42.7%	110	45.7%	98	44.4%	0.537	0.744	0.801
female	158	43.5%	109	45.2%	98	44.3%			
missing	50	13.8%	22	9.1%	25	11.3%			
Age									
15-65	196	54.0%	111	46.1%	119	53.8%	0.045*	0.738	0.120
65+	159	43.8%	126	52.3%	101	45.7%			
missing	8	2.2%	4	1.6%	1	0.5%			
Ischemic stroke (ICD10: I63, I64)									
male	8,888	44.3%	9,630	44.7%	10,225	45.2%	0.379	0.152	0.264
female	9,221	45.9%	9,811	45.6%	10,423	46.1%			
missing	1,961	9.8%	2,095	9.7%	1,971	8.7%			
Age									
15-65	5,692	28.4%	5,940	27.6%	6,189	27.4%	0.064	0.016*	0.581
65+	14,279	71.1%	15,516	72.0%	16,357	72.3%			
missing	99	0.5%	80	0.4%	73	0.3%			

Stroke (ICD10: I60, I61, I62, I63, I64)									
male	9,043	44.3%	9,740	44.7%	10,323	45.2%	0.371	0.139	0.276
female	9,379	45.9%	9,920	45.6%	10,521	46.1%			
missing	2,011	9.8%	2,117	9.7%	1,996	8.7%			
Age									
15-65	5,888	28.4%	6,051	27.8%	6,308	27.6%	0.015*	0.004*	0.659
65+	14,438	71.1%	15,642	71.8%	16,458	72.1%			
missing	107	0.5%	84	0.4%	74	0.3%			
Overall ambulance deliveries (without COVID-19)									
male	316,618	38.7%	327,081	38.9%	372,144	39.2%	0.009*	<0.001*	<0.001*
female	332,182	40.6%	340,076	40.4%	393,422	41.5%			
missing	169,057	20.7%	174,270	20.7%	182,764	19.3%			
Age									
15-65	424,215	51.9%	430,253	51.2%	482,786	50.9%	<0.001*	<0.001*	<0.001*
65+	350,751	42.9%	367,252	43.6%	424,655	44.8%			
missing	42,891	5.2%	43,922	5.2%	40,889	4.3%			

**Significant*

Table 7. Number and distribution of COVID-19 screenings and COVID-19-related deliveries by the NAS between 2020 and 2021.

	2020		2021		2020/2021
	N	**%**	**N**	**%**	**P-value**
COVID-19 screenings done by the ambulance					
Gender					
male	36,738	9.4%	495,871	42.5%	<0.001*
female	55,563	14.2%	670,056	57.5%	
missing	299,155	76.4%	5	0%	
Age					
15-64	345,913	88.4%	1,009,088	86.6%	<0.001*
65+	45,432	11.6%	156,811	13.4%	
missing	111	0%	33	0%	
COVID-19-related ambulance deliveries					
Gender					
male	31,840	44.1%	53,458	45.1%	<0.001*
female	32,909	45.5%	55,594	46.9%	
missing	7,501	10.4%	9,432	8.0%	
Age					
15-64	33,546	46.4%	59,149	50%	<0.001*
65+	37,748	52.3%	59,165	49.9%	
missing	956	1.3%	170	0.1%	

**Significant*

Table 8 demonstrates that the number of acute myocardial infarction (AMI) related deliveries significantly increased between the 2019/2020 ($p < 0.001$) and 2019/2021 ($p < 0.001$) data. However, no significant change was observed between 2020 and 2021 ($p = 0.815$). A similar pattern emerged for haemorrhagic stroke, albeit with a negative correlation. A significant decrease was detected when comparing 2019/2020 ($p < 0.001$) and the 2019/2021 data ($p < 0.001$), but no significant difference was found when comparing the 2020 and 2021 data ($p = 0.268$). The deliveries of ischemic stroke cases consistently and significantly rose yearly ($p < 0.001$).

Since most stroke cases were classified as ischemic, all stroke deliveries also significantly increased annually ($p < 0.001$). Overall, non-COVID-19 deliveries significantly rose from 817,857 cases in 2019 to 841,427 cases in 2020 ($p < 0.001$) and continued to increase considerably to 948,330 cases in 2021 ($p = 0.005$). COVID-19 screenings and COVID-19-related ambulance deliveries experienced a significant increase from 2020 to 2021 ($p < 0.001$).

Table 8. Comparative analysis of COVID-19 screenings and various types of deliveries by the NAS between 2019 and 2021 Source: Own elaboration

		2019 weekly data	2020 weekly data	2021 weekly data	2019/2020	2019/2021	2020/2021
					P-value	P-value	P-value
Acute myocardial infarction (ICD10: I21, I22)	**N (yearly data)**	3,161	3,545	3,524	<0.001*	<0.001*	0.815
	Mean	60.8	68.2	67.8			
	SD	9.5	10.8	11.1			
	Median	61.5	69	66.5			
	IQR	12	16	12.5			
	Shapiro-Wilk	0.036	0.640	0.574			
Haemorrhagic stroke (ICD10: I60, I61, I62)	**N (yearly data)**	362	240	219	<0.001*	<0.001*	0.268
	Mean	7.0	4.6	4.2			
	SD	3.1	2.0	1.7			
	Median	6.5	4	4			
	IQR	5.25	3	2.25			
	Shapiro-Wilk	0.050	0.293	0.902			
Ischemic stroke (ICD10: I63, I64)	**N (yearly data)**	20,017	21,441	22,581	<0.001*	<0.001*	<0.001*
	Mean	384.9	412.3	434.3			
	SD	30.8	25.2	32.1			
	Median	384.5	417.5	430			
	IQR	45.5	39.75	41.5			
	Shapiro-Wilk	0.593	0.526	0.068			
Stroke (ICD10: I60, I61, I62, I63, I64)	**N (yearly data)**	20,379	21,681	22,800	<0.001*	<0.001*	<0.001*
	Mean	391.9	416.9	438.5			
	SD	31.7	25.5	31.8			
	Median	390	421.5	435			
	IQR	46.5	40	42			
	Shapiro-Wilk	0.571	0.626	0.074			
Overall ambulance deliveries (without COVID-19 deliveries)	**N (yearly data)**	817,857	841,427	948,330	<0.001*	<0.001*	0.005*
	Mean	15,728.0	16,181.3	18,237.1			
	SD	670.9	1,014.9	1,882.5			

	Median	15,570.5	16,364.5	18,096			
	IQR	858.5	1,071	1,806			
	Shapiro-Wilk	0.140	0.203	0.168			
COVID-19 screenings done by the ambulance	**N (yearly data)**	0	387,116	1,168,890	N.A.**	N.A.**	<0.001*
	Mean	N.A.**	7,444.5	22,478.7			
	SD	N.A.**	15,028.5	19,958.9			
	Median	N.A.**	0	15,426.5			
	IQR	N.A.**	0.25	29,035.75			
	Shapiro-Wilk	N.A.**	<0.001	<0.001			
COVID-19 related ambulance deliveries	**N (yearly data)**	0	71,512	118,508	N.A.**	N.A.**	<0.001*
	Mean	N.A.**	1,375.2	2,279.0			
	SD	N.A.**	1,442.3	2,380.6			
	Median	N.A.**	843	1,683.5			
	IQR	N.A.**	1,492	3,258.25			
	Shapiro-Wilk	N.A.**	<0.001	<0.001			

**Significant*

A display that the weekly average of AMI-related deliveries steadily increased over the three years and reached its zenith at the onset of the second COVID-19 wave (Figure 3). The upper 95% standard deviation threshold was also surpassed during this peak. The R-squared value was a mere 0.073, partially due to the lack of significant difference ($p = 0.815$) in the number of deliveries between 2020 and 2021, as shown in Table 8. Figure 3b demonstrates that the weekly average of stroke-related deliveries increased considerably. The peak occurred during the third wave, during which the upper 95% standard deviation threshold was breached multiple times. With an R-squared value of 0.2197, the linear trend exhibited a better fit to the data points than AMI. The weekly moving average of overall non-COVID-19-related ambulance deliveries is illustrated in Figure 3c.

The lower 95% standard deviation threshold was nearly exceeded during the lockdown of the first COVID-19 wave, following which the weekly moving average of deliveries consistently increased. The peak occurred during the third wave, after which the deliveries did fall below the upper 95% standard deviation threshold.

The R-squared value of the linear trend was 0.4008. A low degree of all the R-squared values for the weekly variations may have also played a role. Figures 4a and 4b depict the weekly moving average of COVID-19 screenings and COVID-19-related ambulance deliveries, respectively. The intensity of these activities corresponds with the COVID-19 waves. Concerning AMI, no significant changes in gender and age distribution could be found.

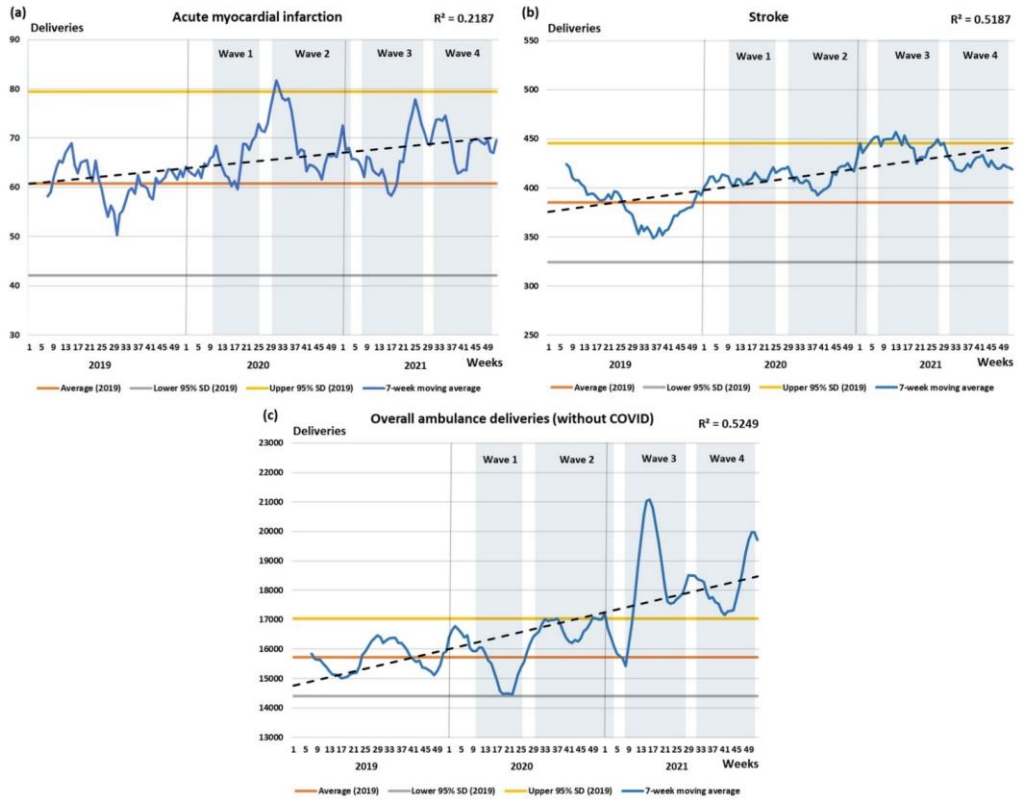

Figure 4. Weekly moving average of (a) acute myocardial infarction, (b) stroke, and (c) overall non-COVID-related deliveries by the NAS between 2019 and 2021. The upper and lower standard deviations are calculated based on the 2019 data. The R-squared values of the linear trends are shown in the upper right corners.

Source: [38]

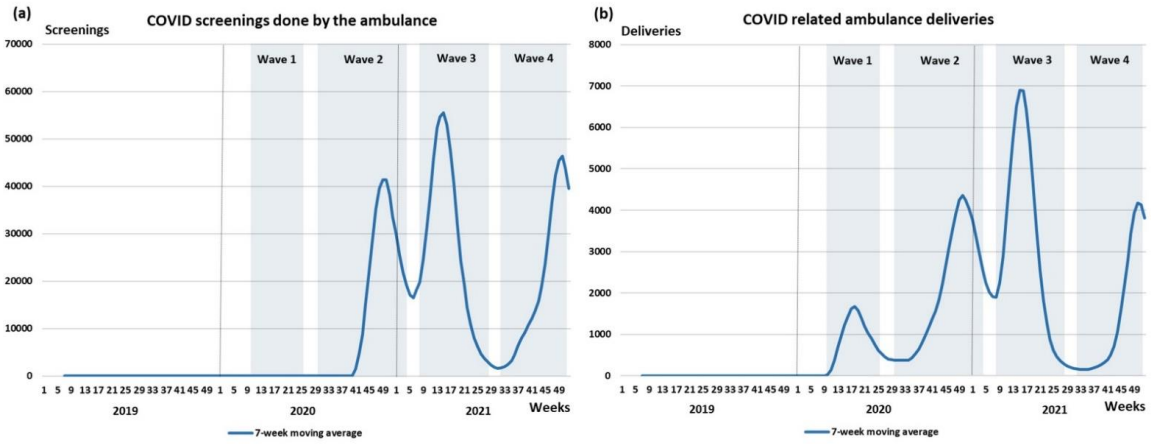

Figure 5. Weekly moving average of (a) COVID-19 screenings and (b) COVID-19-related deliveries by the NAS between 2019 and 2021.

Source: [65]

V. Discussion

The sustainability of the Hungarian healthcare system is currently facing critical challenges, among which accessibility and professional shortages are of paramount concern. Despite the system providing free access for citizens, practical availability is increasingly constrained, and the shortage of professionals is intensifying for multiple reasons. Concurrently, the private health sector -typically unable to deal with more expensive and complex diseases- is gaining prominence. The public system is afflicted by a lack of resources and a deficiency of doctors and healthcare workers, posing a severe challenge to the safety and quality of healthcare provision [58]. A healthcare system transformation is imperative to promote sustainable operation and development alongside the augmentation and equitable distribution of public resources. The state must formulate a financing structure considering the healthcare sector's resource needs. The National Ambulance Service, as Hungary's largest state-operated healthcare provider, also confronts these issues. An ideal modern healthcare system should comprise centralised super hospitals and community-integrated primary care with well-trained physicians and specialised staff with broader authority to alleviate the burdens on doctors. However, the current trajectory does not support this model; it increasingly channels primary care towards centralisation, and despite healthcare workers obtaining university-level education, they are granted only limited intervention rights, with many tasks unnecessarily restricted to physicians. A spectacular example is the newly organised out-of-hours GP services by NAS.

From July 1, 2022, in Hajdú-Bihar county, the NAS began operating the out-of-hours GP services, initially supported by an EU grant [59]. Under the state-run ambulance service, there is no change for patients in accessing out-of-hours GP services, but their calls are now received at the NAS call centre. This enables immediate high-level intervention in acute life-threatening situations, as the highest level of assistance can be dispatched to the patient based on unified alert principles. Based on the pilot program's success, a national restructuring of the emergency system commenced, except Budapest. By March 1, 2024, the NAS will provide primary care emergency duties nationwide, making emergency care provision a state responsibility. In January 2024, the new emergency system will be provided in seventeen counties, excluding Fejér and Pest counties. In Hungary, paramedics currently do not have the authority to prescribe medications despite frequently using various drugs during emergency callouts. This limitation significantly affects paramedics' quality, efficiency, and professional recognition. Their training and competencies are of a high standard, allowing them to make effective and responsible decisions in emergencies. Their role in emergency care is indispensable for maintaining care quality and safeguarding patients' lives, especially given the current workforce situation. The restriction on prescription rights negatively impacts the quality and efficiency of emergency care. The lack of prescribing authority prevents paramedics from fully utilising their professional skills, leading to several issues [60]

The inefficiency arises as paramedics cannot immediately provide necessary medications to patients, causing delays and potentially diminishing treatment effectiveness. Faster medication interventions could reduce waiting times and congestion in emergency care. Additional costs may be incurred in the healthcare system and for patients.

Due to the paramedics lack prescription rights, patients may need to consult different doctors, generating extra costs for both the healthcare system and patients, affecting the system's efficiency and overloading healthcare providers. Several proposals to address the issues arising from the lack of prescription rights for paramedics could be considered by policymakers. Extending prescribing rights to paramedics appears to be the most straightforward solution, potentially increasing emergency care efficiency, improving communication, and enhancing patient care quality. Consequently, paramedics could respond more quickly and effectively to patient’s conditions, reducing potential complications and hospital treatment durations. Developing protocols and collaborative agreements among healthcare providers could facilitate efficient communication between paramedics and physicians, reducing the risk of information loss. Moreover, strengthening professional collaboration could improve emergency care coordination and the efficiency of comprehensive patient management. Enhancing training and continuing education for paramedics ensures they have current knowledge of medication-related decision-making and optimal patient care. Continuous education informs paramedics about the latest medical treatments and appropriate diagnostic and therapeutic methods for patient conditions.

Measures to improve the work of The National Ambulance Service are essential because they are the first responders in emergencies and, therefore, play a vital role in reducing the number of avoidable deaths in the health service. This research on geographic inequality constitutes a pioneering analysis of the correlation between amenable mortality and ambulance service delivery at the county level within Hungary.

It unveils pronounced variances across counties, with several exhibiting mortality and delivery rates nearly double the national mean. These discrepancies, however, are contingent on the type of disease. The geographic disparities in mortality rates within Hungary suggested similar patterns might exist in ambulance service delivery [53]. Notably, Borsod-Abaúj-Zemplén county exhibited a marked disparity, demonstrating significantly higher mortality rates from hemorrhagic strokes, contrasted with notably fewer stroke-related ambulance deliveries. It is pertinent to note that Borsod-Abaúj-Zemplén is one of the most socioeconomically disadvantaged counties in Hungary, a factor that may have influenced these outcomes [61].

The insights from this study hold significant implications for policymakers, particularly in highlighting the potential for enhanced optimisation of resource allocation in ambulance services. Furthermore, the critical nature of amenable mortality warrants increased attention from decision-makers, as it presents tangible opportunities to prevent such fatalities [45-47]. In addressing this, the consideration of ambulance deliveries and the rectification of identified service disparities become crucial.

Additionally, the research underscores the necessity for the National Ambulance Service's management to intensify the implementation of checklist-based disease debriefings and oversee this protocol while training rescue managers and operational personnel. Such an approach would facilitate informed decision-making regarding the dispatch location and the competency level required of the responding rescue unit, thereby ensuring care at the highest attainable standard.

Based on the outcomes of the analysis, the operational team of the National Ambulance Service is positioned to recommend optimal allocation strategies for ambulance units to the senior management, thus aiding in the rational and professional redistribution of vehicles. Nonetheless, this study is not without its limitations. For instance, the multifaceted aetiology of cardiovascular diseases under examination was not accounted for. Therefore, the data concerning mortality and ambulance delivery at the county level may not directly translate to individual patient outcomes, precluding the establishment of a causal link between mortality rates and ambulance service delivery. Furthermore, the scope of the study was confined to the county level, as data from the Hungarian ambulance service were accessible in this format, thus limiting the potential for a more granular analysis of municipalities based on urbanisation levels and geographical positioning. Another consideration is the uniformity of patient transport coverage provided by the Hungarian ambulance service across the country, despite the variability in professional standards and equipment among healthcare providers in different regions, which could influence the rates of avoidable mortality.

Consequently, the primary goal of our research was to highlight the significance of efficient ambulance service operations and the potential for diminishing disparities in this sector.

Throughout the COVID-19 pandemic, there was a notable escalation in the rescue operations conducted by the National Ambulance Service in Hungary. Particularly during the third wave of the pandemic, the NAS was subjected to considerable operational demands. Given that acute myocardial infarction and stroke primarily constitute public health concerns, it becomes imperative for the healthcare system to prioritise the organisation and implementation of such rescue missions [53,54].

In contrast, a previous study from Britain focused solely on the pandemic's first wave and did not report an increase in ST-elevation myocardial infarction and stroke-related rescue activities [43]. Our research aligns with these findings, as we, too, did not witness a substantial rise in rescue activities during the initial wave of COVID-19. This observation might be attributed to the compensatory decrease in rescue demands due to the pandemic lockdown, potentially leading to fewer incidents like motor vehicle accidents and sports-related injuries [62]. The National Ambulance Service (NAS) utilises a variety of instruments to achieve optimal performance, notably Business Intelligence (BI). BI represents a technologically driven methodology for data analysis, providing critical and actionable insights that assist executives, managers, and operational personnel in making well-informed business decisions [63].

During the COVID-19 pandemic, countries with smaller ambulance units performed better than those with a singular, more extensive service. Under their localised presence, small ambulance services are inherently more agile. They can respond more rapidly to emergencies, particularly in geographically dispersed or rural areas where more extensive services may face logistical challenges. This increased responsiveness is crucial in time-sensitive medical emergencies, where every minute can significantly impact patient outcomes. Additionally, more minor, advanced medical units, which prioritise on-site treatment over emergency room transfers, can offer more personalised care and are often better integrated into their communities, facilitating a deeper understanding of local health needs and cultural nuances [64]. This community-centric approach can enhance the overall effectiveness of pre-hospital care.

Moreover, the decentralised nature of multiple small units allows for a more adaptable and resilient system that maintains operations even if one unit faces challenges, thereby ensuring continuous coverage across regions.

Therefore, deploying numerous small ambulance services potentially offers a more efficient, responsive, and community-tailored approach to emergency medical care than a centralised, more extensive service. Additionally, using multiple small ambulance services minimises the risk of cross-infection in more prominent, centralised facilities, a critical consideration in controlling the spread of COVID-19. Thus, the operational flexibility, enhanced coverage, and reduced infection risk associated with small ambulance services render them a potentially more effective option during the pandemic.

VI. Summary

The Hungarian healthcare system confronts critical sustainability challenges, prominently marked by accessibility issues and a shortage of medical professionals. Free access, in theory, is contradicted by practical constraints and escalating professional deficits. The state's financing model must reflect healthcare needs, a principle echoed by the National Ambulance Service (NAS), Hungary's principal state-run healthcare entity. This research is the first to investigate the relationship between amenable mortality and ambulance deliveries at the county level in Hungary. It reveals significant disparities among counties, with some showing mortality and delivery rates nearly double the national average, varying by disease type. Hungary's study on geographic disparities indicates substantial inter-county variation in amenable mortality and ambulance deliveries. Notably, Borsod-Abaúj-Zemplén County reported high hemorrhagic stroke mortality alongside reduced ambulance deliveries, reflecting socioeconomic factors. These insights inform resource optimisation and highlight the significance of addressing service disparities to prevent avoidable fatalities. Despite these findings, limitations persist, such as the study's county-level focus, which may not represent individual outcomes, and the non-inclusion of cardiovascular diseases' multifactorial. The analysis of the NAS during the COVID-19 pandemic illustrates the organisation's effective management and strategic resource allocation. It reflects the NAS's commitment to providing prompt and efficient emergency medical services, adapting to the evolving needs and challenges of the pandemic, and ensuring the safety and well-being of the communities it serves.

Nevertheless, the study accentuates the critical role of efficient ambulance service operation and the opportunity to reduce disparities in emergency healthcare delivery.

The research emphasises the need for efficient ambulance service operations and highlights the importance of resource allocation and service disparity in influencing avoidable mortality rates. It also suggests the need for improved training and decision-making in ambulance services. The thesis presents critical findings that shed light on the challenges and disparities in Hungary's healthcare system, providing evidence-based recommendations for policy development. A key observation is the substantial geographic variation in ambulance deliveries and mortality rates, with some counties exhibiting figures nearly double the national average. Disease-specific analysis revealed distinct spatial patterns, necessitating tailored approaches for each condition. The COVID-19 pandemic significantly impacted emergency rescue operations, emphasizing the importance of adaptive capacity planning. During the second wave in 2021, the National Ambulance Service (NAS) experienced a notably higher workload compared to the first wave in 2020, reflecting the correlation between epidemic severity and rescue activity frequency. This underscores the need for epidemic monitoring to inform resource allocation. Notably, conditions like acute myocardial infarction (AMI) and hemorrhagic stroke displayed unique trends, indicating that temporal analyses must account for disease-specific characteristics. Collectively, these findings highlight critical areas for intervention to enhance healthcare delivery and emergency response systems.

Finally, future research should examine the effectiveness of resuscitation in NAS activities. It can also focus on the NAS time of arrival and the time of transport to the definitive medical facility, and the time from patient admission to care to get a complete picture of the indicators supporting the reduction of avoidable deaths.

A further direction of research could be to compare mortality data by county for the diseases studied and to examine the rescue activities of the NAS to see whether the NAS has used its resources appropriately and whether, despite the increased workload, mortality rates have not increased and care for priority diseases has not been compromised.

VII. Összefoglalás

A magyar egészségügyi ellátórendszer kritikus fenntarthatósági kihívásokkal küzd, az elméletben biztosított szabad hozzáférés a szakemberhiány miatt korlátozott. A hozzáférhetőség az egyik kiemelt példája a rendszerben meglévő hiányosságoknak hiszen az ellátói oldalon fennálló probléma direkten jelenik meg az igénybevevők részén is. Az állami finanszírozásnak reflektálnia kellene az állampolgárok egészségügyi szükségleteire. Az Országos Mentőszolgálat, Magyarország legnagyobb állami egészségügyi szolgáltatójaként rendkívül kitett a hiányosságoknak azonban sokat is tud tenni a javulásért. Ez a kutatás az első, amely Magyarországon megyei szinten vizsgálja az elkerülhető halálozás és a mentőszállítások kapcsolatát. Kutatásunk jelentős területi eltéréseket tárt fel mindkét vizsgált mutató kapcsán. Számottevő eltéréseket fedeztünk fel a megyék között, kiugró példa, hogy egyes régiókban betegségtípustól függően közel kétszeres a halálozási és a hozzá kapcsolódó szállítási arány az országos átlaghoz képest. Kiemelkedően magas Borsod-Abaúj-Zemplén vármegyében a vérzéses stroke halálozási aránya annak ellenére, hogy a régióban alacsonyabbak a mentési számok, a betegségtípus esetén. A halálozások megfelelnek a feltételezett szocioökonómiai tényezőknek, de a mentési tevékenységeknek nem kell egyenesen arányulnia ezekhez. Az eredmények hangsúlyozzák az erőforrások optimalizálásának szükségességét és a mindenki számára hozzáférhető egészségügyi ellátás fontosságát az elkerülhető halálozások megelőzése érdekében. A tanulmány korlátja, hogy, az adatok megyei szinten kerültek feldolgozásra, amely nem tükrözi az egyéni tényezőket, figyelmen kívül marad a szív- és érrendszeri betegségek sokténye zős etiológiája.

Az elemzés COVID-19 járvánnyal foglkozó része bemutatja a mentőszervezet hatékony megküzdését és stratégiai erőforrás-allokációját. Ez kiemeli az OMSZ elkötelezettségét a gyors és hatékony sürgősségi orvosi ellátás biztosítása mellett, alkalmazkodva a járvány változó igényeihez és kihívásaihoz, biztosítva az általa szolgált közösség biztonságát.

Kutatásunk hangsúlyozza a hatékony mentőszolgálat szükségességét és kiemeli az erőforrás-allokáció fontosságát az elkerülhető halálozás csökkentésében. Végül a jövőbeli kutatások fókuszában lehet az OMSZ tevékenységei közül az újraélesztés hatékonysága, és összpontosíthat a betegek prehospitális ellátásának megkezdésétől a kezelés során eltelt teljes időre, hogy teljesebb képet kaphasson a tudományos közösség az elkerülhető halálozások csökkentését igazoltan támogató mutatókról.

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IX. Keywords

amenable mortality, health indicators, Hungarian National Ambulance Sevice, prehospital care

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