SHORT THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PHD)

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

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I. Introduction

Hungarian health indicators are among the EU's lowest, with significant disparities in life expectancy, infant and maternal mortality rates, and chronic disease prevalence across income groups. Cardiovascular diseases particularly afflict Hungary, with high mortality and hypertension rates. Lifestyle risk factors, such as smoking and poor diet, contribute heavily to mortality. Also, the healthcare system faces challenges like limited access, quality issues, and inefficient resource use, exacerbated by an outdated structure and regional disparities. Experts call for systemic reforms to address these issues and improve overall health outcomes.

Amenable mortality offers insights into healthcare system efficacy, distinguishing between avoidable deaths preventable by healthcare versus those preventable through public health measures. In 2018 a Spanish study introduced indicators for assessing amenable mortality, focusing on diseases identifiable by symptoms alone. Hungary's amenable mortality rates are among the EU's highest, highlighting the need for focused improvement in healthcare quality. Research underscores the importance of addressing amenable mortality to enhance health outcomes, with disparities evident across socioeconomic and geographical lines in Hungary. Effective healthcare system transformation is crucial for reducing preventable and amenable death rates, aiming for better health and longevity across Europe.

Healthcare systems encompass three levels: primary, specialised, and special care, with the latter including services like home care and ambulance services. Ambulance services play a crucial role in pre-hospital acute care despite diagnostic and environmental challenges. Effective ambulance services are vital for reducing morbidity, as outcomes heavily depend on the speed of professional healthcare intervention. Despite global challenges, including the misuse of ambulance services for primary care, the proficiency of these services is critical. Researches worldwide highlights the impact of ambulance response times and service efficiency on patient outcomes, underscoring the need for performance evaluation and strategic resource allocation within ambulance services.

The Hungarian National Ambulance Service (NAS), established in 1948 with roots back to 1887, has evolved from a "patient to hospital" to a "hospital to patient" model, emphasising on-site stabilisation. Entirely government-funded, NAS is critical for handling medical emergencies, especially for conditions like stroke and acute myocardial infarction (AMI). It also focuses on reducing pre-hospital delays in reperfusion therapy and maintaining uniform service quality through standardised procedures. The service's performance, essential for addressing amenable mortality and ensuring timely interventions, underscores the need for equitable healthcare delivery and minimising geographic disparities in care access.

II. Objectives of our research

Our research aimed to investigate the operational efficacy of the Hungarian 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 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. 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. Hungary's population is characterised by markedly poor health outcomes, particularly in the "early death stage of life" within the 25–64 age group. This situation necessitates a focused analysis of deaths associated with health services in the 15–64 age demographic. The second part of the research focuses on acute myocardial infarction, hemorrhagic stroke, and ischemic stroke, 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. 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. 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. 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.

IV. Results

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 NAS conducted 369,672 emergency deliveries. Our 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, 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. Furthermore, these counties also experienced substantially elevated AMI-related ambulance deliveries compared to the national average. 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. Notably, lower hemorrhagic stroke mortality rates were identified in the capital (Budapest), Pest county, and Vas county. In these regions, hemorrhagic stroke-related ambulance deliveries were also significantly reduced. Conversely, Szabolcs-Szatmár-Bereg county experienced significantly higher hemorrhagic stroke mortality rates, 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 while simultaneously displaying a markedly lower rate of hemorrhagic stroke-related ambulance deliveries. Our data indicates 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, Pest county, and Zala county. Correspondingly, these regions also experienced significantly reduced ischemic stroke-related ambulance deliveries. In contrast, significantly higher ischemic stroke mortality rates were detected in Békés, Borsod-Abaúj-Zemplén, Heves, Jász-Nagykun-Szolnok, Nógrád, and Szabolcs-Szatmár-Bereg counties. Moreover, these counties experienced notably higher ischemic stroke-related ambulance deliveries than the national average.

From January 2019 to December 2021, the Hungarian National Ambulance Service (NAS) conducted 2,798,348 emergency deliveries for patients aged 15-64, including 190,734 COVID-19 cases. Additionally, the NAS performed 1,557,388 COVID-19 screenings. The number of acute myocardial infarction related deliveries significantly increased between the 2019/2020 and 2019/2021 data. However, no significant change was observed between 2020 and 2021. A similar pattern emerged for haemorrhagic stroke, albeit with a negative correlation. A significant decrease was detected when comparing 2019/2020 and the 2019/2021 data, but no significant difference was found when comparing the 2020 and 2021 data. The deliveries of ischemic stroke cases consistently and significantly rose yearly. 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. The upper 95% standard deviation threshold was also surpassed during this peak. 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. The lower 95% standard deviation of overall non-COVID-19-related ambulance deliveries 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 intensity of these activities corresponds with the COVID-19 waves. Concerning AMI, no significant changes in gender and age distribution could be found.

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. 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.
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. 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.
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.

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. 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. Our research 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.

VI. New scientific results of the dissertation

Pillar I: Investigating the Geographic Disparities of Amenable Mortality and Related Ambulance Services in Hungary.

1. Thesis: Regional Analysis of the Performance of the National Ambulance Service (NAS).

Research has revealed significant regional disparities in rescue metrics and mortality rates in Hungary. In some counties, these ratios were nearly double the national average.

2. Thesis: Importance of Temporal and Spatial Analysis of Diseases.

Temporal and spatial analyses help identify regional differences and patterns that significantly impact patient outcomes. The analysis of the diseases examined highlights that rescue times, geographical location, and accessibility regional differences considerably influence patient outcomes.

II. Pillar: The Emergency performance of the Hungarian ambulance service during the COVID-19 pandemic

3. Thesis: The Impact of COVID-19 on NAS Rescue Activities.

The COVID-19 pandemic significantly increased the number of certain rescue activities while decreasing others, highlighting that capacity planning is a critical factor for ambulance services during public health emergencies.

4. Thesis: Increased Load on NAS During the Second Wave of COVID-19.

During the second wave of COVID-19 in 2021, NAS faced a much higher load compared to the first wave in 2020, demonstrating an indirect relationship between the severity of the pandemic and the frequency of rescue activities. Monitoring the pandemic's progression is thus crucial for effective capacity planning.

5. Thesis The Necessity of Separate Analysis of Disease Types.

However, this observation does not apply to acute myocardial infarction (AMI) and hemorrhagic stroke, indicating that disease types must be examined separately in temporal analyses.

VII. 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. The Hungarian 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. Finally, future research should examine the effectiveness of resuscitation in NAS activities. It can also focus on the NAS time of arrival, 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.

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List of publications related to the dissertation

1. Bíró, K., **Deák, M. S.**, Pápai, G., Nagy, A. C., Dombrádi, V., Szabó, G. T., Boruzs, K., Bányai, G., Csató, G.: The Emergency Performance of the Hungarian Ambulance Service during the COVID-19 Pandemic.
   Healthcare. 10 (11), 1-10, 2022.
   DOI: https://doi.org/10.3390/healthcare10112331
   IF: 2.8
2. **Deák, M. S.**, Csató, G., Pápai, G., Dombrádi, V., Nagy, A. C., Nagy, C., Juhász, A., Bíró, K.: Investigating the Geographic Disparities of Amenable Mortality and Related Ambulance Services in Hungary.
   Int. J. Environ. Res. Public Health. 18 (3), 1-8, 2021.
   DOI: http://dx.doi.org/10.3390/ijerph18031065
   IF: 4.614

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List of other publications

3. Lovas, D., **Deák, M. S.**: Az egészségügyi rendszer "Achilles-sarkai": az egészségügyi szakdolgozók és a finanszírozás helyzete Magyarországon.
   Med. Jur. 14 (3), 11-17, 2023.
4. Oluma, F. A., Sunday, G. T., Mohammed, K., **Deák, M. S.**, Boruzs, K., Bíró, K., Bányai, G.: The role of the World Health Organisation and related funds on maternal and child health in Nigeria.
   egis. 2 (2), 14-31, 2023.
   DOI: http://dx.doi.org/10.56626/egis.v2i2.12965

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