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COVID-19 pandemic in Budapest and the V4 capitals[1]

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Abstract

Cities and urban regions played a decisive role in the novel coronavirus pandemic. On the one hand, they often became infection hotspots due to their high population density or high intensity of social interactions. On the other hand, cities, as centres of healthcare, provided the highest level of medical services throughout the pandemic. This study focuses on Central and Eastern European (CEE) capital cities, including Budapest. The paper is structured into three major parts. Following the introduction, the methodological chapter provides relevant information on the statistical indicators applied. The literature review summarizes the most important research antecedents on the topic. The results section presents an international comparison based on V4 capitals (Warsaw, Prague, Bratislava, and Budapest). The paper concludes with several recommendations derived from the primary findings intended to inform local decision-makers.

The article primarily analyses the available epidemiological indicators on COVID-19 morbidity, mortality and vaccination. The international statistical comparison encompasses the territorial units of the V4 capitals. On the other hand, the paper also includes a literature review to present the most important results of prior research.

[1] The paper is based on a part of the book chapter titled Annamária Uzzoli – Gábor Pirisi: Budapest in the COVID-19 Pandemic, which was published in the book titled Szirmai, Viktória (ed.): Budapest metropolis. A Central European metropolitan area (L'Harmattan, Budapest, 2024, 288–313.) (in Hungarian). The present article was created by supplementing and further developing the content of this book chapter.

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Among the key findings, it can be mentioned that Budapest apparently exhibited a partly contradictory, paradoxical position among the V4 capitals. Based on confirmed coronavirus cases, it occupied a mid-range position among the CEE capitals during the main pandemic years (between 2020 and 2022), but mortality rate attributable to the infection was disproportionately high, relative to the population size. At the same time, Budapest's epidemic situation was more favourable when compared to other regions within the national spatial structure.

Keywords: COVID-19, epidemic indicators, V4, spatial structure, Budapest

Absztrakt

A városok és a városi térségek meghatározó szerepet játszottak az új típusú koronavírus-járványban. Egyrészt gyakran váltak fertőzési gócpontokká a sűrűn lakott terek és társadalmi interakciók magas száma miatt. Másrészt a városok egyúttal, mint egészségügyi központok, legmagasabb szintű egészségügyi szolgáltatásokat nyújtották a járvány idején. A tanulmány középpontjában a kelet-közép-európai fővárosok, köztük Budapest van. A tanulmány három fő szerkezeti részből áll. A bevezetés után a módszertani fejezet releváns információkat szolgáltat az alkalmazott statisztikai mutatókról. Az irodalmi áttekintés fejezete összefoglalja a vizsgálati téma legfontosabb kutatási előzményeit. Az eredmények fejezete egy nemzetközi összehasonlítást mutat be a V4 fővárosok (Varsó, Prága, Pozsony, Budapest) alapján. A tanulmány végén az elsődleges következtetések segítségével néhány javaslatot fogalmazunk meg, amelyek a helyi döntéshozók számára lehetnek fontosak.

A cikk alapvetően a COVID-19-járvány a morbiditással (megbetegedéssel), a mortalitással (halálozással) és vakcinációval (átoltottság) kapcsolatos járványügyi mutatókat dolgozza fel egy statisztikai elemzés keretében. A nemzetközi statisztikai összehasonlítás a V4 fővárosokat foglalja magában. Ugyanakkor a tanulmány szakirodalmi feldolgozást is tartalmaz a legfontosabb kutatási előzmények bemutatására. A főbb eredmények között említhető, hogy Budapest részben ellentmondásos, paradox helyzete volt tapasztalható a V4-es fővárosok között a világjárvány idején. A regisztrált koronavírus-esetek alapján a fő járványévekben (2020 és 2022 között) a kelet-közép-európai fővárosok középmezőnyében helyezkedett el, de a fertőzés miatti halálozások aránya népességarányosan kiemelkedő volt. Ugyanakkor Budapest járványügyi helyzete kedvezőbb volt a hazai térszerkezetben.

Kulcsszavak: COVID-19, járványügyi mutatók, V4, térszerkezet, Budapest

Introduction

Almost six years after the outbreak of the coronavirus pandemic, many previously unknown or insufficiently explored interrelations are still emerging, continuously expanding our knowledge and understanding of the epidemic. These include insights derived from international comparisons, as they can also contribute to future prevention and protection against similar epidemic situations at the national level.

Major historical epidemics have left many legacies for Budapest, and this was also the case with the most recent pandemic. The epidemic and the responses and reactions it triggered will undoubtedly persist over the long term, and may open a new chapter in the future of the Hungarian capital. The COVID-19 pandemic has affected cities worldwide in a multitude of ways and the outcomes have been analysed in the literature by many people and in many different ways during recent years (e.g. Pirisi 2022, Pirisi et al. 2022), including the analysis focusing on Budapest. Nevertheless, the evaluation of Budapest's international position within the broader context of the epidemic – for some reasons – has received less attention.

The present study seeks to address this gap by undertaking a comparative analysis of the capitals of Central and Eastern Europe (CEE), with particular emphasis on the Visegrad Four (V4) countries (Poland, Czech Republic, Slovakia, Hungary), using key epidemiological indicators. It should however be emphasized, that this paper does not aim to discuss other – social, economic, environmental, political, health etc. – consequences of the epidemic.

Cities and urban regions played a decisive role in shaping the dynamics of novel coronavirus pandemic (Florida 2020; Tešić et al. 2020). High number and rate of local population or density rate (Stier et al. 2021) coupled with social interactions (Angel et al. 2020) in urbanized regions significantly influenced the emergence and progression of epidemic waves (Szirmai et al. 2022, 2023). Furthermore, the strong functional linkages between cities and their agglomerations – such as daily commuting – were critical drivers in the spatial diffusion of novel coronavirus (Gu et al. 2020).

From an international perspective, Hungary exhibited a contradictory epidemic profile, particularly when compared with other Central and Eastern European (CEE) countries in terms of the number of confirmed COVID-19 cases and mortality. While Hungary ranked in the mid-range for infections per capita during the main epidemic years (2020–2022), it recorded some of the highest coronavirus-related mortality rates (Pál et al. 2021). Among the V4 (Poland, Czech Republic, Slovakia) and other larger neighbouring countries (Serbia, Romania), Hungary reported the highest mortality rate (2.3%), considerably exceeding the European average (0.8%) (Uzzoli 2022). Against this backdrop, a central question arises: how can Budapest's position be defined within the spatial structure of the V4 capitals?

Data and methods – Possibilities and limitations

From research perspective, one of the most significant challenges of the COVID-19 pandemic was the establishment of adequate databases that enable regional-level analyses as well. While this issue may appear tangential to the main topic, but in order to understand the later results and to mitigate any perceptions of incompleteness that may arise in the reader, it is important to highlight the uncertainties of the data used and the limitations of publicly available epidemic data sources. These constraints apply equally to international datasets.

With respect to COVID-19-related epidemic data, it is important to emphasize that European countries applied heterogeneous procedures for testing, case registration, and mortality reporting. These methodological discrepancies may have influenced the comparability and interpretation of statistical outcomes.

Official or governmental epidemic data platforms – although varying across countries –, typically provided online geoinformatics applications, that facilitated the monitoring of the spatial evolution of key epidemiological indicators across multiple territorial scales. In most cases, the finest available resolution corresponded to the LAU 1 level, which in Hungary is equivalent to districts.

In contrast, Hungary's official, governmental epidemic data service primarily operated at the national scale, posing in this way particular challenges for the acquisition of district level (LAU 1) data suitable for international comparison. Nevertheless, this spatial level was identified as the most appropriate for comparative analysis of the V4 capitals.

The official epidemic data service in Hungary included only a limited set of epidemic indicators disaggregated by the capital city and other territorial units of the country (e.g. number of active cases, cumulative deaths and recoveries). These datasets were later supplemented through public interest data requests. This resulted in additional regionally analysable databases which were compiled by civil society organizations and public portals. Moreover, these databases are still publicly accessible today (e.g. https://atlo.team/koronamonitor/, https://bit.ly/COVID-adatok), unlike the official website koronavirus.gov.hu shut down on January 1, 2023. This official governmental portal was last updated on December 28, 2022, and owing to the absence of further data revisions was eventually archived on Facebook (https://www.facebook.com/koronavirus.gov.hu).

In the settlement databases supplementing the official data release, Budapest generally appeared as a single aggregated unit, which was adequate for international comparison. Incidentally, district-level analyses of Budapest were beyond the scope of this study. All supplementary data ultimately originated from the National Centre for Public

Health and Pharmacy, although these figures were not officially disclosed by the government. Another significant challenge in managing these territorial datasets was their temporal inconsistency, which necessitated substantial efforts in harmonization and cleaning before an internationally comparable database could be established. Ultimately, a comprehensive dataset was compiled, covering all confirmed infections in Budapest between March 4, 2020 and December 31, 2021, and on all COVID-19-related mortalities between March 4, 2020 and January 31, 2022.

For international comparison the analysis was focused on the capitals of the V4 countries – Warsaw (Poland), Prague (Czech Republic), Bratislava (Slovakia), and Budapest (Hungary) – with Berlin included as a benchmark city. The rationale for selecting the V4 capitals lies in their comparable population size, agglomeration and urban characteristics, and broadly similar development trajectories, while Berlin was chosen as a reference city because its population size is at least double that of the V4 capitals and its socio-economic profile differs significantly from theirs.

International data reporting was not standardized, and similar difficulties were encountered in building the database for the comparative analysis to the Hungarian one. The level of detail, resolution, and temporal coverage of the available epidemic data varied significantly between the examined cities. However, in all these examined capitals – just like in the case of Budapest – data were obtained for the administrative boundaries of the capital alone, excluding their respective metropolitan areas. The primary data sources for statistical analysis were daily official statistical portals in each country, which reported daily figures on confirmed infections and mortality, in the majority of cases.

Specifically, these sources included:

- *Czech Republic:* Ministerstvo Zdravotnictví České Republiky (MZCR, 2023)
- *Poland:* Ministerstwo Zdrowia Rzeczypospolitej Polskiej (MZRP, 2023)
- *Germany:* Robert Koch Institute (RKI, 2023)
- *Slovakia:* Magistrate of the Capital City of the Slovak Republic Bratislava (MCCSRB, 2023)
- *Hungary:* koronavirus.gov.hu (2022)

In addition, scientific publications containing relevant and usable data on this topic (e.g. Komenda et al. 2020) were consulted. The analysis was facilitated by the fact that capital cities generally constitute separate administrative units in their national territorial structures.

Another difficulty arose from the lack of temporal alignment across international datasets, as reporting periods did not start or end simultaneously. For instance, epidemiological data for Warsaw were only available from January 1, 2021, while reporting

for Bratislava ceased in April 2022. Consequently, the international database covered the period between mid-March 2020 and the end of December 2022. In this context, infection and, to a lesser extent, mortality data were available for a longer period at the capital level.

However, COVID-19 mortality data were only available for Berlin, Budapest and Prague, which restricted the comparative analysis of this epidemic indicator for these three cities only. Although data on the age distribution of cases, hospitalizations, ventilator use, or intensive care unit treatments on a daily basis were publicly available in several of the examined countries, these indicators could not be compared due to the absence of equivalent data for Budapest. Unfortunately, vaccination statistics were also unavailable at the city level, limiting comparability only to national-level data sourced from the website of the UN World Health Organization, so they became comparable at least at the level of the examined countries.

In summary, similar to Hungary, the other CEE countries examined faced numerous challenges and limitations in epidemiological data collection and analysis, which should be considered when interpreting and evaluating the results. Consequently, testing practices and activity varied widely across countries, so substantial discrepancies are likely to exist between the numbers of registered (officially confirmed) and actual infections both in Hungary and internationally. Moreover, as the COVID-19 pandemic evolved, the emergence of new variants causing increasingly milder symptoms brought new epidemic waves, as quite a few patients remained undetected by the healthcare system (since a significant number of individuals did not undergo testing or refrained from seeking medical attention even after obtaining positive results from home tests).

In addition to statistical analysis, literature review was also one of the applied research methods in our paper. The evaluation of the major research findings on this topic helped to contextualize Budapest's epidemiological position within the broader CEE framework.

Literature review

The primary objective of this literature review is to assess the role of Central and Eastern European (CEE) capitals in COVID-19 pandemic based on the most relevant antecedent studies. First of all, it is important to note that the number of available publications specifically focusing on the epidemic situation of CEE capitals during the pandemic is relatively limited. The majority of existing studies primarily address the economic impacts of the pandemic on these capitals (e.g. Boros et al. 2020; Czech et al. 2020; Kovács et al. 2020; Tosics 2020; Módosné et al. 2025; Pál 2025).

It is generally true, that epidemic outbreaks are more likely to occur in urban areas, where high population density, constant and intensive personal interactions can generate infection hotspots (Chang et al. 2020). Beyond these structural characteristics, a city's geographical location and its role within the global urban network are also important factors in determining whether a local outbreak evolves into a worldwide pandemic (Brockmann 2020; Szirmai 2021, 2022).

Direct air connections between Wuhan and major cities in North America and Western Europe essentially determined the initial transmission pathways of the novel coronavirus in the globalized world and thus facilitating the rapid escalation of the pandemic (Gonne, Hubert 2020). In comparison to major Western European cities, the capitals of CEE occupied secondary or even tertiary position in the global urban network, which delayed the virus's arrival in this region. Nevertheless, the capitals of this region, as regional transport hubs, became national epicentres of the infection and facilitated the diffusion of the virus within their respective countries (Igari 2023).

It was a general phenomenon in CEE countries that during the first wave, the majority of registered infections concentrated in capitals and large cities, with a slight positive correlation and co-movement between population density and the number of registered COVID-19 cases, indicating that the two variables exhibited similar spatial dynamics. However, from the second wave onwards, this urban–rural disparity diminished significantly, leading to a more spatially balanced distribution of cases (Kovalcsik et al. 2021).

Although during the epidemic waves, the scope and intensity of containment measures varied among CEE countries, but the strictest interventions were typically implemented in the capitals (Uzzoli 2022). For example, in Berlin, a large-scale demonstration was organized against the pandemic-related restrictions in autumn 2020. In Prague, lockdown measures were typically applied in two-week cycles, accompanied by a rotation system in schools and even by a temporary suspension of public Wi-Fi services. On 1 April 2020, 38 hospitals and hospital departments across Poland – including twelve in the Masovian Voivodeship which encompasses Warsaw as well – were temporarily closed due to confirmed or suspected SARS-CoV-2 contamination. Slovakia was among the first to implement comprehensive, nationwide restrictions during both the first and second waves covering the entire country, including the capital city. Budapest adopted a partially proactive approach, introducing several public health measures during the first wave, which were only later adopted at the national level (Uzzoli, Pirisi 2024).

In fact, the outbreak of the COVID-19 pandemic in Hungary is closely associated with Budapest, due to its prominent role in the international transport network, as a major air transport hub. While the city constituted the country's primary infection hotspot during the first wave of the epidemic, it did not maintain this status, in proportion to its

population in the subsequent waves (Uzzoli et al. 2021; Pál, Uzzoli 2024). At the national level, Budapest's epidemiological position among the Hungarian cities proved relatively favourable when assessed by key epidemiological indicators (Uzzoli 2025; Uzzoli, Pirisi 2024). Nevertheless, the city's epidemiological vulnerability was inherently elevated due to several structural and demographic factors, including its global connectivity, extensive urban fabric and relatively old age composition, even though this higher vulnerability was not fully reflected in the measured epidemic data.

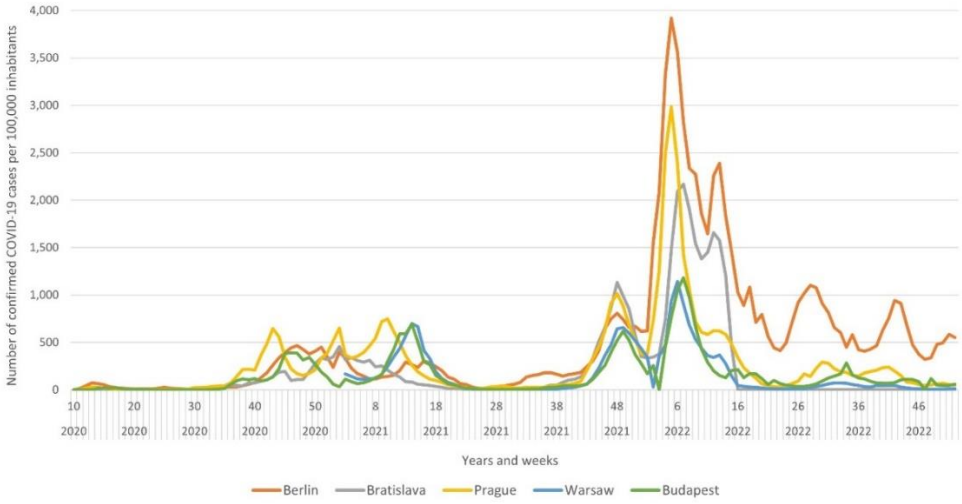
Results – Budapest's position among V4 capitals in relation to the COVID-19 pandemic

An analysis of the weekly number of newly confirmed infection cases reveals that the examined cities studied were largely synchronized with epidemic waves and infection peaks occurring in a broadly similar pattern, typically with a maximum delay of only a few weeks *(Figure 1)*. However, certain differences can also be observed: for example, the number of 'wave peaks' and 'wave troughs' that developed between autumn 2020 and spring 2021 varied among the examined capitals. While Budapest and Berlin each experienced two epidemic peaks, Bratislava recorded only one, whereas Prague had three. Moreover, in Prague, the troughs between successive epidemic peaks were less pronounced, whereas in Berlin, the epidemic wave associated with two distinct novel coronavirus variants manifested more as extended epidemic plateaus, rather than sharp peaks. By contrast, the progression of epidemic waves between autumn 2021 and spring 2022 exhibited a high degree of similarity across the examined cities. The peak with the highest number of confirmed infections occurred in early 2022, after which case numbers in the V4 capitals declined steadily and stabilized at relative low levels by the end of spring 2022. Berlin, however continued to exhibit additional, though progressively weaker, peaks even during the spring of 2022. Figure 1 also clearly illustrates a prolonged trough lasting several months between the end of the third wave and the onset of the fourth wave in the summer of 2021.

Further divergences can be observed between the cities in the magnitude of confirmed infection cases. At the height of the early 2022 peak, the number of new infections per 100,000 inhabitants per week reached nearly 4,000 in Berlin, and approximately 3,000 in Prague. By comparison, this figure in Budapest only briefly exceeded 1,000. In other words, at the peak of the epidemic, weekly infection rates corresponded to roughly 1% of the population in Budapest and Warsaw, approximately 2% in Bratislava, 3% in Prague and 4% in Berlin based on confirmed cases. Beyond these differences in magnitude, the overall temporal pattern of the epidemic curve in Budapest showed extremely strong similarities to that observed in Warsaw.

Figure 1.

Daily number of new confirmed COVID-19 cases per 100,000 inhabitants per week, March 1, 2020 – December 31, 2022



Data source: MZCR, 2023; MZRP, 2023; RKI, 2023; MCCSRB, 2023; koronavirus.gov.hu 2022; Komenda et al., 2020.
Note: Data for Warsaw were available only from January 2021.

The cumulative number of confirmed infections also reflects similar variations among the examined cities *(Figure 2)*. By the end of the official daily data report period (1 May, 2022), the cumulative infection rate in Budapest did not exceed 20% of its population (transmission rate), whereas in Berlin this value approached 80%. It is important to emphasize that due to reinfections, these figures do not imply that four out of five inhabitants in Berlin were infected, or that only one in five residents of Budapest contracted COVID-19.

Further disparities – primarily between Berlin and the other capitals – –can be attributed to the evolving nature of the pandemic. Two key factors underpin these differences:

1) Vaccination coverage: by late 2021 vaccinations and revaccinations (booster uptake) had become widespread, with at least 60% of the population vaccinated in the countries observed;
2) Emergence of the Omicron variant: From early 2022, the Omicron strain spread globally, characterized by a lower risk of severe illness (milder symptoms).

These two reasons led to a significant decrease in the number of (registered) new infections and a plateauing of cumulative cases in the capitals studied from spring 2022 onwards. The sole exception is Berlin, where cumulative case numbers continued to rise. This divergence in Berlin is likely attributable to social factors rather than an actual worsening of the epidemic situation.

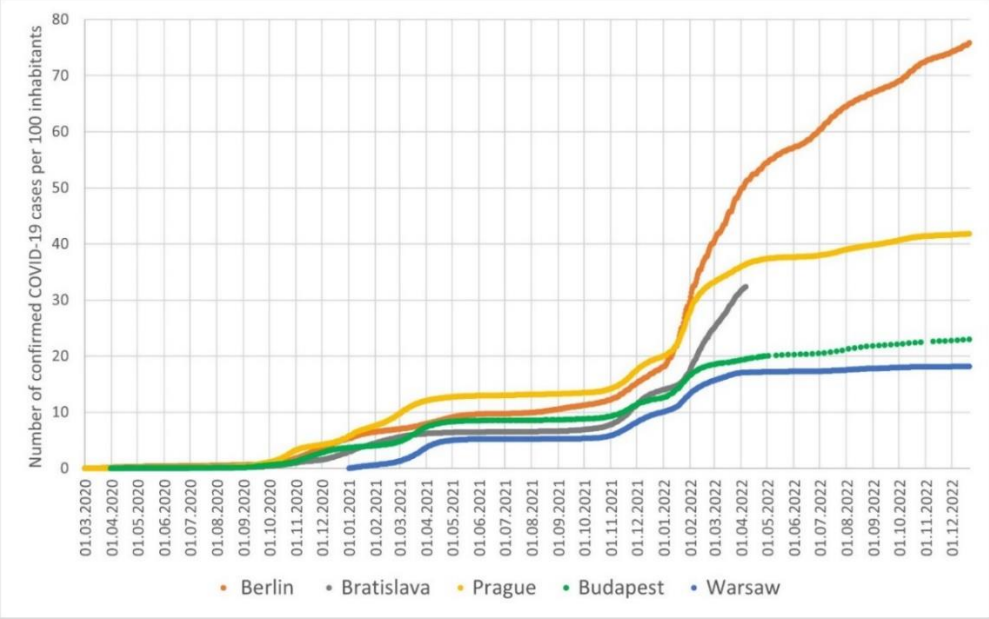
Finally, by the second half of 2022 the pandemic had slowly subsided across the region and most countries discontinued official reporting in early 2023. Consequently, our statistical analysis focuses only on epidemic data up to the end of 2022. Although a minor wave occurred in autumn 2022, it involved comparatively fewer new cases, largely due to hidden morbidity – patients experiencing mild symptoms who did not seek medical care, remained undiagnosed, or relied on home rapid tests without reporting positive results.

Overall, clear differences emerged between two 'city pairs' – Budapest and Bratislava versus Prague and Berlin, based on the examined epidemic indicators. These variations likely reflect genuine differences in epidemiological dynamics rather than artifacts of data collection.

Nevertheless, it is essential to reiterate a critical caveat highlighted earlier in this paper: patient screening, case registration, and mortality reporting protocols during the epidemic varied substantially among countries. These inconsistencies undoubtedly also influenced the apparent trajectory of the pandemic in the examined capitals. In the assessment of the epidemic data, it must also be taken into account that the official statistics captured only confirmed cases, while the actual total number of cases was almost certainly several times higher.

Figure 2.

Total number of confirmed COVID-19 cases per 100 inhabitants per month, March 1, 2020 – December 31, 2022



Data source: MZCR, 2023; MZRP, 2023; RKI, 2023; MCCSRB, 2023… koronavirus.gov.hu 2022; Komenda et al. 2020.

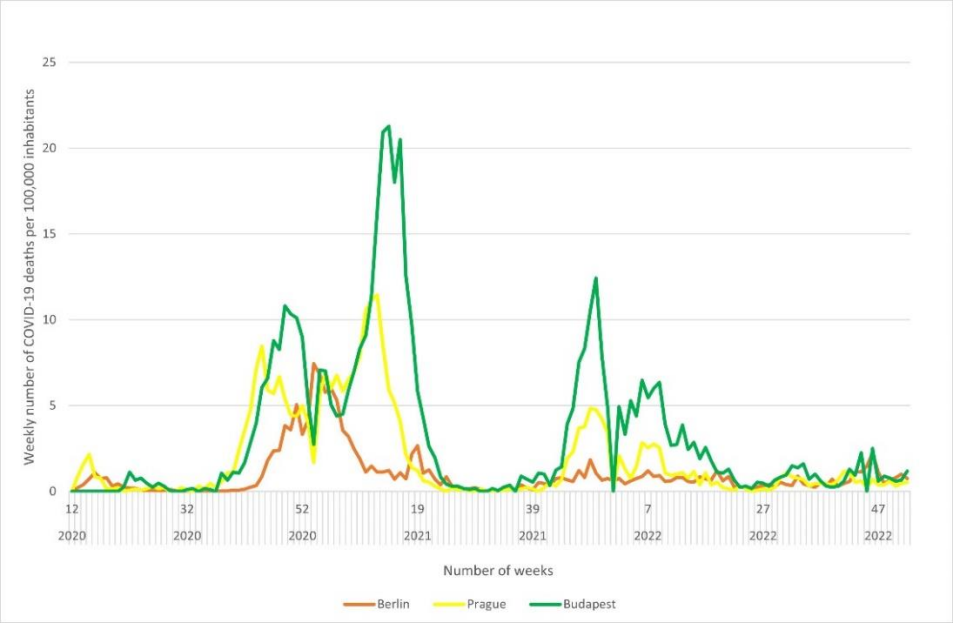
Note: Data for Warsaw were available only from January 2021 and cumulative values were calculated by summing the daily case numbers. Consequently, differences in absolute values should be interpreted with caution.
The dotted line for Budapest indicates that, after 1 May, 2022, domestic epidemic data were released on a weekly basis. Therefore, for the Hungarian capital, monthly statistics are derived from the aggregated weekly data, rather than the sum of daily values as in the other examined capitals.

When evaluating Budapest's COVID-19 situation among the examined capitals based solely on the number of confirmed infections, it appears that the Hungarian capital was less affected by the epidemic than the others or occupied a mid-range position compared to other Central European capitals. However, this seemingly favourable assessment changes significantly when mortality data are taken into account. Although due to the unavailability of reliable epidemic data, Bratislava and Warsaw were excluded from the mortality comparison, the analysis clearly indicates that Budapest exhibited the highest mortality rate per 100,000 inhabitants among the examined capitals between

early 2020 and the end of 2022 *(Figure 3)*. The difference can safely be called dramatic: approximately 7,800 deaths were registered in Budapest, compared with about 3,500 in Prague and 5,200 in Berlin.

Figure 3.

Weekly COVID-19 deaths per 100,000 inhabitants, March 1, 2020 – December 31, 2022



Data source: MZCR, 2023; RKI, 2023; koronavirus.gov.hu 2022.

Note: Publicly available and reliable data on COVID-19 deaths were not accessible for Bratislava and Warsaw.

Berlin's population is roughly twice that of Budapest. However, during certain weeks between 2020 and 2022, relative epidemic indicators showed that mortality rates in Budapest were three to four times higher than in the German capital. Considering the relatively low number of confirmed infections in Hungary *(see Figures 1 and 2)*, this implies that an infected resident of Budapest was approximately 12 times more likely to die from COVID-19 than an infected resident of Berlin, based on officially reported data.

This interpretation, however requires caution. Mortality statistics are subject to considerable uncertainty, as European countries employed different protocols for attributing deaths to COVID-19. Consequently, the number of reported COVID-19 deaths may not

always fully correspond to the actual number of pandemic-related fatalities in these countries.

Thus, the regional differences in the population-based number of COVID-19 deaths could also be explained by the different medical protocols for determining deaths caused by the infection in the V4 countries. The various administrative exercises can actually be conceptualized along a continuum: At one extreme, deaths were counted if the individual was infected at the time of death; at the other, only cases where COVID-19 was the primary cause (e.g., respiratory failure directly induced by infection) were included in the statistics. Between these two extremes (as the ends of the scale), numerous intermediate approaches and local protocols existed not only across Europe but also globally. Obviously, when assessing epidemic data, it is crucial to account for the variation in national protocols for classifying COVID-19-related deaths. Evidence suggests that in Hungary, deaths were more frequently attributed to COVID-19, in comparison to several other countries. Thus, in Hungary, the official statistics directly included all deaths linked to confirmed COVID-19 infection, which may partly explain the higher mortality figures. Nevertheless, differences in reporting protocols alone cannot account for Budapest's substantially higher COVID-19 compared to other capitals.

Overall, if we previously noted that part of the difference in infection between Budapest and the other cities was actually attributable to lower transmission, a similar observation applies to the COVID-19 mortality data: there is a real, structural reason behind these figures. The disparity cannot be explained solely and exclusively by differences in statistical methodologies (e.g. variations in medical protocols).

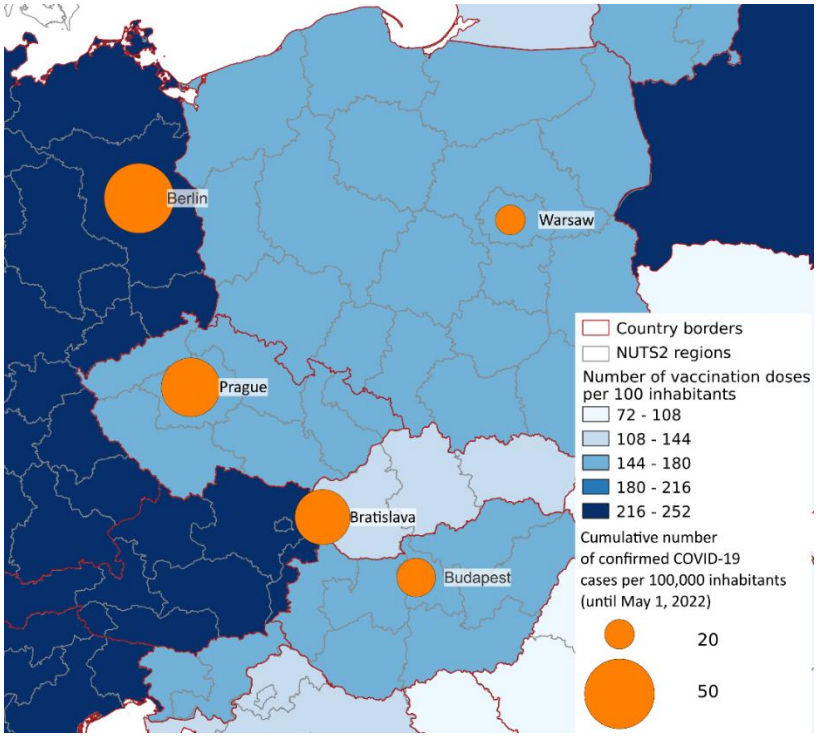
When comparing the main socio-economic indicators of Budapest and Berlin, it becomes evident that both cities have aging populations. According to the 2022 census, 21.2% of Budapest's population was aged 65 years or older, compared to 18.9% in Berlin (Statistik Berlin-Brandenburg 2023). Not only does aging itself play a role, but also factors, such as lower life expectancy and the poorer overall health among the elderly population, which can largely explain the mortality-gap, assuming equal healthcare quality, although the assumption of equal healthcare quality in the two cities may not reflect reality.

Differences among the examined capitals were observed not only in COVID-19 infections and mortalities, but also in vaccination rates and vaccination willingness. Within Central Europe, German-speaking countries led the way in vaccination coverage, while the V4 countries also performed well overall, with the exception of Slovakia. In general, the examined countries occupied a favourable position regarding vaccination willingness and vaccine availability, although they slightly lagged behind more developed

countries (e.g. Germany, Austria) *(Figure 4)*. Based on the cumulative number of confirmed COVID-19 cases per 100,000 inhabitants, Budapest ranked similarly to Warsaw, both at the lower end of spectrum.

Figure 4.

Total COVID-19 deaths per 100 inhabitants in the V4 capitals and Berlin (as of May 1, 2022), and country-level vaccination coverage (doses per 100 inhabitants) in 2023



Data source: WHO Coronavirus (COVID-19) Dashboard (https://COVID19.who.int/table, https://covid19.who.int/) 2023.

It is important to note that the capitals of Central Eastern and Europe (CEE), including Berlin, no matter how similar they are to each other, possess distinct characteristics that may partly explain epidemiological differences. For example, Berlin is not only the largest, but also the most densely built-up city: with a population density exceeding 4,000 people/km^2 despite its extensive areas of green space and aquatic areas. The population density of Bratislava, Prague and Warsaw ranges between 1,300 and

2,600 people/km^2 (citypopulation.de), but despite its lower infection rate, Budapest is the second most densely populated among the studied cities with approximately 3,200 people/km^2.

Differences also exist in the level of globalization among the capitals analysed, which in turn affects their direct exposure to infections, but the evaluation of this factor remains somewhat controversial. For example, the KEARNY Report (KEARNY 2022) ranked only Berlin among the top 30 cities (placing it 9th). In contrast, according to the Globalization and World Cities Research Network (GaWC 2023), Warsaw is the most globalized city in the regions examined (Alpha category: 26th place), and Prague also surpasses Berlin in this classification. Both Berlin and Budapest occupy a similar situation and are classified as beta cities. It should be noted, however, that, unlike the V4 capitals, Berlin does not function as Germany's primary international gateway; its airport ranks 25th in Europe in terms of passenger traffic (Warsaw: 32nd, Prague: 45th, Budapest: 49th). Nevertheless, among the capitals analysed, Berlin was typically the first to experience new waves of COVID-19 infections, reflecting the city's advanced integration into global urban networks, despite its stronger political-cultural than economic role within Germany.

Summary

The COVID-19 pandemic has fundamentally transformed everyday life and reshaped the relationship between people and cities. It has highlighted the critical role of urban healthcare systems for a nation's population. The pandemic and the resulting crisis demonstrated, that in optimizing the operation and capacity of healthcare services, preparation for similar epidemic situations is essential, and national, as well as local decision-making must continuously adapt to evolving conditions to effectively address emergencies.

The findings supported the hypothesis that Budapest occupies a contradictory, paradoxical position within the spatial structure of the Central and Eastern European (CEE) capitals (V4). Although the number of COVID-19 infections per capita was not among the highest values among the V4 capitals, the Hungarian capital was in a highly unfavourable position in terms of coronavirus-related deaths during the three main years of the epidemic (2020–2022).

Based on the results of the analysis, several important lessons can be drawn regarding the healthcare system in Budapest in relation to the epidemic situation. These insights, and partly recommendations, can support the Hungarian capital's healthcare system in preparing and mitigating the impact on future potential epidemics.

Greater emphasis must be placed on collection, monitoring and evaluation of accurate and detailed epidemic data at all territorial levels, as well as on ensuring their timely public reporting. Without such data, neither healthcare stakeholders, nor decision-makers, nor scientific researchers, and even nor residents are aware of the current epidemic situation, its effects and the level of overall vulnerability. Informing the population and developing effective crisis communication channels for this purpose is therefore essential. Budapest and its agglomeration, as the largest urban region and population hub in Hungary, can play a leading role in achieving this.

Future efforts must also strengthen cooperation, not only among relevant Hungarian healthcare services but also between Hungarian cities, EU member states and neighbouring capitals. Preparing healthcare services and optimizing their capacities can be supported through the establishment of intersectoral and interregional partnership networks, potentially extending beyond national borders. Partial international coordination of epidemic mitigation measures as well as the exchange of experiences among Central European capitals regarding epidemic response can effectively enhance future anti-epidemic preparedness and prevention. In all of this, Budapest is well positioned to assume an active role in building and operating this international – Central and Eastern European – network.

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