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Study of the factors influencing the survival of COVID-19-infected patients in Győr-Moson-Sopron County

Abstract

This research aims to contribute to a greater understanding of COVID-19 and its effects by assessing the factors influencing the survival of COVID-19-infected patients in the Győr-Moson-Sopron County region. The impact of age, comorbidities, and number of days on a ventilator on the survival of COVID-19-infected patients by gender and regional unit are presented based on anonymized data from the Petz Aladár County Teaching Hospital. Binary logistic regression was used to analyze explanatory variables' separate and combined effects. This study shows that age was the most critical determinant of the survival of COVID-19-infected patients, with an increase in age correlating to an elevated probability of death. No significant regional or gender differences in recovery or survival rates were found. This paper, which is grounded in the existing research, offers new insights into the progression of COVID-19 throughout its many waves throughout the region, the impact of local socioeconomic development on medical outcomes, and the relevance of specific comorbidities.

Keywords: COVID-19, spatial differences, survival probability, causality

JEL Codes: C20, C21, I11

INTRODUCTION

Several studies in the national and international literature have presented research results identifying the underlying factors for the possible outcomes of a COVID-19 infection.

Previous studies (Lutz et al., 2023; Ozyilmaz et al., 2022; Sannigrahi et al., 2020) aimed to determine the factors influencing the spread of COVID-19 infection and the dynamics of associated fatalities. Among the factors explaining transmission and mortality, a prominent role was attributed to indicators suitable for describing the state of society, the economy, and the healthcare system. Additionally, individual health conditions and sociodemographic variables characteristic of each person also played a significant role. These studies have established that the presence of primary diseases, in particular hypertension, and inadequate treatment of these diseases may exacerbate the consequences of the pandemic and increase patient mortality. Limitations in healthcare quality and care capacity also increase the likelihood of mortality. Overburdened health systems can also lead to suboptimal care and higher mortality rates.

Another important finding is that there is evidence that socioeconomic disadvantage and poverty are associated with increased COVID-19 mortality (Dukhovnov–Barbieri, 2022). Regional differences and geographical location may have an impact on COVID-19 mortality rates. Inland and peripheral areas show different mortality rates. Another critical factor is the proportion of older people in a population, with a greater number of older people corresponding to increased COVID-19 death rates. Additionally, the presence and sufficient number of health professionals can be crucial to addressing and reducing COVID-19 mortality. As would be expected, countries or areas with a shortage of adequately trained health professionals saw higher COVID-19 mortality rates.

In this study, we add to the state of knowledge by presenting our results on the impact of age, number of concomitant diseases, and number of days on a ventilator on the survival of COVID-19-infected patients in part of Hungary, disaggregated by region and gender.

There was an observable relationship between COVID-19 infection or mortality and various variables, including health status, age, gender, the number of comorbidities, educational attainment, and employment type. Additionally, the study considered aspects of the healthcare system, such as specific infrastructural and human characteristics, social and economic factors, and variables describing the built and natural environment. The analysis aimed to determine whether there was a connection between COVID-19 infection or mortality for the entire variable set or specific subsets of these variables. Our focus was on examining the impact of age, the number of comorbidities, and the duration of days on a ventilator on COVID-19 infection and its outcomes, along with potential gender and regional differences.

The analyses were based on a sample of anonymized data from the Petz Aladár University Teaching Hospital recorded between 2020 and 2022, specifically focusing on the Győr-Moson-Sopron County region. The statistics of the COVID-19 waves are not disaggregated in this study due to the nature of the analysis. The entire study period is treated as one uninterrupted timespan.

1. FACTORS AFFECTING THE SURVIVAL OF COVID-19-INFECTED PATIENTS

Several authors have investigated the influence of factors on the outcome of COVID-19 infection. These studies remain intriguing even after the waves of coronavirus infection have subsided, and they could play a crucial role in preventing further outbreaks and mitigating the harm of a COVID-19 surge. The theoretical part of the study investigates the influencing factors of demographic, climatic, cultural, or socioeconomic differences (including income and total population) to improve infection outcomes and control the spread of COVID-19.

Srikanta et al. (2020) analyzed the global and local spatial connections between key sociodemographic variables and COVID-19 morbidity and mortality in European regions using spatial regression models during the first wave of the pandemic. The spatial analysis and mapping were based on the results of running four spatial regression models: a geographically weighted regression (GWR), a spatial error model (SEM), a spatial lag model (SLM), and an ordinary least squares (OLS) model. In addition, partial least squares (PLS) and principal component regression (PCR) were performed to estimate the overall explanatory power of the regression models. The distribution of confirmed COVID-19 cases and deaths was heterogeneous across Europe. This uneven distribution can be attributed to several relevant factors, including demographic, climatic, cultural, or socioeconomic differences between countries.

The Western European region (Spain, Italy, France, Germany, United Kingdom, Belgium, and the Netherlands) had the highest number of COVID-19 cases and deaths (actual values and per capita). In contrast, the Eastern European region (Romania, Bulgaria, Greece, Estonia, Latvia, and Lithuania) and the Northern European region (Norway, Finland, and Sweden) had lower numbers of cases and deaths (actual values and per capita). This mortality difference can be attributed to the sociodemographic composition of these countries, as Italy has the second oldest population in the world (23% of Italians are 65 years old or older) and the oldest in Europe. The statistical data suggest that for an unbiased estimate and practical interpretation of the results, it is necessary to consider the rates of COVID-19 infection and COVID-19 recovery rate, accounting for relevant factors, which would show a more logical and reliable estimate than an absolute infection/mortality rate.

Srikanta et al. (2020) found that several spatial regression models, including GWR, OLS, SLM, SEM, and others, have been used to explain the spatial non-stationary distribution of COVID-19 cases/deaths and to investigate their spatial dependence. The number of COVID-19 cases and deaths were considered dependent variables for regression modelling. All explanatory variables showed statistically significant, locally varying associations with COVID-19 cases/deaths. The highest associations were found in Germany, Austria, Italy, Spain, Luxembourg, and Croatia. In the Srikanta study, a strong positive correlation was found between income and total population and COVID cases/deaths, indicating that these two factors may be the critical responsible variables determining the total number of COVID-19 fatal and non-fatal cases in 19 European countries.

Ehlert (2021) examined the relationship of regional-level socioeconomic, demographic, and health variables with COVID-19-related cases and deaths in Germany during the first wave until mid-June 2020. His analysis is a retrospective ecological study at the level of 401 administrative districts and district cities (counties) in Germany, with populations ranging from about 34,000 (Zweibrücken) to about 3,664,000 (Berlin). The results showed that the sole proportion of people needing care did correlate to infection and mortality rates. In contrast, the effect of the density of people employed in the care sector on both outcomes is significantly positive. These results are even more interesting because they support the anecdotal evidence from the media that nursing homes are hotspots for the spread of COVID-19, and these results distinguish between different outcomes for residents and staff.

However, our data do not distinguish between home-based day-care and nursing homes. Factors well known in the literature to correlate with reduced COVID-19 infection and mortality rates include higher educational attainment, better access to medical care, and the information advantage associated with a higher income. However, at the population level, the beneficial effects of these may be reduced, non-existent, or reversed (especially in the early stages of a pandemic). High levels of economic prosperity are often based on networking (including physical networking), travel, and social contacts, such as teamwork with colleagues or working in open offices – all of which increase the likelihood of contracting COVID-19. In other words, the accoutrements and necessities of wealth may either increase or decrease COVID-19 infection and mortality rates, depending upon circumstances.

A study by Ramirez et al. (2022) draws on statistics collected in 33 OECD countries and three other European countries (Bulgaria, Malta, and Romania). Their results show that lower health system capacity, higher population density, air pollution, elderly population, and lower institutional quality are significantly associated with higher excess mortality at the regional level.

Morshed and Sarkar (2021) examined the causes and common determinants of COVID-19 morbidity and mortality in the 50 countries most affected by the first wave. Obesity rates, the percentage of the population aged 65 and over, and the number of hospital beds per 1,000 population had a significant and positive correlation with infection and mortality.

Ozyilmaz et al. (2022) examined the impact of social and health indicators on morbidity and mortality during the COVID-19 pandemic. Using data from 93 countries, they created a model with five social and health indicators that were found to predict COVID-19 cases and deaths. The number of tourists, the population aged 15-64, and institutionalization positively correlated with the spread of infection and the number of cases in an area. In addition, cigarette consumption correlated positively with the number of cases in people aged 50 years and older, and vaccination rates positively correlated with the number of cases in people aged 25-75. Findings on social indicators of COVID-19 death rates show that higher average life expectancy rates for a region inversely correlate to the number of deaths in the 25-50 age group and that the proportion of the population aged 65 and over positively correlates with the number of deaths.

According to Kovács and Uzzoli's (2020) research, which was conducted following the first wave of the pandemic, districts in the Hungarian interior and those far from major urban areas saw worse COVID-19 outcomes than their more developed peers. Districts in Hungarian county capitals are in a better position due to the central location of health facilities. Budapest has the advantage of more accessible access to central health facilities. Poorer health and health conditions were found in districts with no outpatient clinics or only one in the district headquarters. In the Hungarian Great Plain districts, accessibility indicators are more favorable due to the lower number of small and underdeveloped settlements. In general, higher accessibility values were found in the vicinity of the county capitals, as there were no or few outpatient clinics in the neighbouring districts.

Due to the pandemic, the number of check-ups, screenings, and surgeries decreased, and people have avoided healthcare institutions. This lack of regular health care impacts the health system, with an increased role for telemedicine, home care, and private care. In the long term, missed interventions and services can lead to worse health outcomes and increases in preventable deaths. Regular medical check-ups are essential for chronic patients but were difficult to arrange or remained unscheduled during the pandemic. Lack of screening reduces the chances of survival from cancer, and fear of infectious disease can lead to psychosomatic illnesses. An increase in symptoms and medical conditions not caused by COVID-19 may still be said to be an indirect result of the pandemic, which has severely harmed those who are unable to care for their other illnesses. Access to care remains a problem, and improving it is essential if poor health outcomes are to be effectively addressed. The on-call system of general practitioners must be strengthened, and care must be made more widely available to patients in remote areas.

According to Simonyi (2020), international and national experience suggests that old age and underlying cardiovascular and metabolic diseases worsen COVID-19 prognosis and increase mortality. Diabetes mellitus has been shown to increase the risk of adverse outcomes in COVID-19. These adverse outcomes can be reduced by preventing infection and ensuring compliance with hygiene and spacing rules. Additionally, careful control of blood sugar and insulin levels in patients with diabetes is essential for both the overall health of the patient and COVID-19 survival and recovery.

Kékes et al. (2020) reported that patients with hypertension saw worse recovery outcomes than those without, which does not establish that hypertension alone is at fault. The majority of confirmed COVID-19 cases are in the age group between 30 and 70 years. However, mortality is concentrated in the upper age boundaries of this group and above—those over 60. Among hypertensive patients, analyses have shown that hypertension comorbidities, such as diabetes, coronary artery disease, stroke, or chronic kidney disease, increase the likelihood of major morbidity and mortality. Kékes et al. also found that treatment with ACEI/ARB (angiotensin-converting enzyme inhibitors and angiotensin receptor blockers) does not appear to increase the risk of severe COVID-19 events or death. They suggest that although a positive association between hypertension and COVID-19 infection and its outcome severity has been found, hypertension alone does not appear to be a major risk factor for more severe COVID-19 cases or death. That said, comparing mortality rates across diverse populations can be difficult due to differences in data-gathering and analytical techniques.

Kovács and Vanus (2022) investigated factors determining differences in COVID-19 mortality rates across Hungarian districts. An increase in the female population aged 65 and over, a decrease in the number of nurses per 10,000 people, and an increase in the number of job seekers per 10,000 people showed a correlation with an increase in COVID-19 mortality rates. The positive correlation with the job seeker rate can presumably be explained by the fact that unemployment can be treated as an inverse indicator of the prosperity (and likely overall health) of the district's population. This indicator variable has a significant COVID-19 mortality-increasing effect alongside outpatient and inpatient care status variables. In Hungary, communities with disproportionate elderly populations are typically less developed, with younger people moving to more prosperous urban areas to find work. Thus, this positive old-age/COVID-19 mortality correlation may suggest a relationship between poverty and COVID-19 mortality rates.

In another study, Páger et al. (2023) investigated the geographic distribution of coronavirus-related mortality and explored the role of socioeconomic variables in its background. Their statistical analyses, based on ordinary least squares (OLS) and spatial regression analysis, were performed at the district level (175 districts) between the onset of the pandemic in Hungary and 31 January 2022. Their results show that the registered COVID-19 mortality was higher in areas with a higher-than-average proportion of older adults and a higher pre-pandemic prevalence of respiratory-related mortality. Districts with a greater-than-average number of college-educated people tended to have lower rates of deaths due to the coronavirus. However, contrary to most of the literature (including several studies mentioned above), access to health care did not significantly explain district-level recorded COVID-19 mortality rates.

Moreover, their results supported the finding that population density and settlement differences emerged as significant explanatory factors in the pattern of COVID-19 mortality. Spatial regression analysis revealed that less developed districts or areas peripheral to larger settlements had higher COVID-19 mortality. In contrast, the opposite was observed in more developed districts (e.g., in the capital region and suburbs).

Lutz et al. (2023) investigated the nature of the differences in the county-specific characteristics of COVID-19 mortality by age in the second year of the pandemic. The adult age pattern of COVID-19 mortality by county and gender was estimated using a Gompertz function with multilevel models. Their results showed that the Gompertz function is suitable for describing county-level patterns of COVID-19 mortality. They did not find significant regional differences in the age progression of mortality but substantial regional differences in mortality levels. Analysis of mortality levels showed a relationship between socioeconomic factors and healthcare indicators in the expected direction but with different strengths.

No factors changed the age-related pattern of mortality. However, significant differences in the level of mortality were found at the county level. COVID-19 mortality was more severe in those living in more deprived areas than in more affluent areas. A negative association was found between the number of doctors working in the county and the level of COVID-19 mortality, but no correlation was found in the analysis of ecological effects. In the more underdeveloped regions of Hungary, the proportion of unfilled GP practices in primary care was generally higher, peaking mainly during the second wave of the pandemic, when doctors over 65 were not allowed to practice. People living in underdeveloped areas visit their doctors less often for various tests and assessments, and they are inherently more isolated and have less access to care, even in ordinary times. The rules required to prevent the spread of coronavirus only exacerbated care-access issues. The level of epidemiological and professional information reaching the population in areas with more limited healthcare access was lacking, and important tests that play a key role in early disease detection were less frequently administered. Effective epidemiological work, such as early disease detection and patient isolation, can only be carried out with well-functioning primary care, which is important in containing the pandemic and reducing its impacts. Due to the comparatively limited level of care in remote areas, untreated underlying diseases may also be more common and more severe in general than in the areas with better care access. Vaccine uptake and coverage are also lower in these remote areas, which may have further exacerbated mortality statistics.

In addition to analysing demographic and severity of illness factors in patients admitted to their intensive care unit (ICU), Koller et al. (2023) examined the impact of treatment modality changes on severely infected patients' outcomes in the third and fourth waves of the COVID-19 pandemic. They conducted a retrospective, observational study to record demographic, clinical, treatment, and outcome data of patients admitted with severe respiratory failure due to coronavirus infection. Data from 88 patients were processed. Fifty-three percent of patients were male, with a median age of 65 and a median BMI of 29. Non-invasive ventilation was used in 81% of cases, endotracheal intubation in 45%, and abdominal inversion in 59% at some point in the treatment process. Vasopressor therapy was required by 44% of patients, and secondary infection control was required by 36%. The survival rate was 41%. Survival risk factors were also assessed using multivariate modelling. In addition to lower age and APACHE II scores, non-diabetic status was associated with a better survival rate. During the pandemic, patients' treatments were continuously changed and updated. Treatment effects were monitored, with treatments found to be more effective being deployed and less effective treatments being discarded, likely leading to improved recovery outcomes after controlling for APACHE II score, gender, BMI, two comorbidities, and the administration of two drugs (remdesivir, tocilizumab).

Based on the presented literature, six main factor clusters can be said to affect the possible outcomes of COVID-19 infection:

1. The impact of health status: Deteriorating health status is associated with increased COVID-19 mortality. The prevalence and lack of treatment of underlying diseases may exacerbate the consequences of the pandemic and mortality.
2. The impact of health care: The level of health care and care capacity may influence the mortality rate of COVID-19. Overburdened health systems can lead to cumbersome care and higher mortality rates. Healthcare workloads, unfilled GP practices, and lack of access to care are associated with higher COVID-19 mortality rates.
3. The impact of socioeconomic factors: Socioeconomic disadvantage and poverty are associated with an increase in the COVID-19 mortality rate. People in more deprived regions may be more vulnerable to the pandemic's impact.
4. Age: An increase in the proportion of older adults is associated with increased COVID-19 mortality. The elderly population is most likely to be severely impacted by the pandemic.
5. Environmental factors: Regional differences and geographical location may impact the mortality rate of COVID-19. Inner and peripheral areas have different mortality rates.
6. The presence of health professionals: The presence and enough health professionals, including doctors and nurses, can be an important factor in managing and reducing the mortality rate of COVID-19. In counties or areas with a shortage of adequately trained health personnel, mortality rates may be higher.

2. EMPIRICAL RESEARCH FINDINGS

2.1. METHODOLOGY

In this study, we examine the impact of age, comorbidities, and the number of days on a ventilator on the outcome of COVID-19 infection, exploring age, gender, and regional differences based on available data.

In the first step, we selected individuals from the available observation dataset for analysis. In the second step, we examined the frequency and distribution of the studied metric-scaled target variables in selected regional, gender, and age groups. The results of the analysis are presented in the sample overview and descriptive statistics section.

According to the results of previous domestic and international studies, an increase in age, the number of comorbidities, and the number of days on a ventilator are associated with an increased likelihood of mortality. In other words, the older the individual, the more comorbidities they have, and the more severe their condition, the higher the chances of a fatal outcome of the infection.

The patient's age, the number of comorbidities, and the number of days on a ventilator are metric variables, and the outcome variable used is non-metric, with varying sample sizes across categories. We employ binary logistic regression to analyze explanatory variables' separate and combined effects. The results are presented following the descriptive statistics.

2.2. DESCRIPTIVE STATISTICS OF THE SAMPLE

The study analyses data recorded by Petz Aladár County Teaching Hospital for 2020-2022. From that dataset, information on 6,151 COVID-19-infected patients, including 3,167 men and 2,984 women, was obtained. Patients under 40 years of age made up 13.5% of the total, 24.1% were between 41 and 60 years of age, and 62.4% were over 60 years of age. Patients discharged to their home after treatment constituted 47.3% of the total, 22% died, and 30.7% had a different status (i.e., transferred to another hospital, institution, or a social home department or were discharged without a doctor's permission). Of the comorbidities recorded in patients, diabetes and hypertension were given priority, and 5.7% of COVID-19-infected patients had diabetes, 36% were hypertensive, and 11.8% had both comorbidities. All five COVID waves are considered in the analysis. One percent of patients were in the first wave, 27.6% in the second wave, 33.3% in the third wave, 18.5% in the fourth wave, and 19.1% in the fifth wave.

The vast majority of the patients (99.3%) were Hungarian citizens, 91.1% had a permanent address in the West Transdanubian Region, 88.8% were in the Győr-Moson-Sopron County region, 57.6% were in the district of Győr, 10.9% in the district of Csorna, and 39.5% were in the city of Győr.

The analyses only considered part of the larger dataset, with three conditions being used to restrict the sample size. The included patients must:

1. have a permanent address in the Győr-Moson-Sopron County region,
2. be registered at the hospital in the period 2020–2022, and
3. have a final status of either deceased or discharged from the hospital.

The first condition defines the geographical space, the second the temporality, and the third the outcome. We considered the address recorded in the hospital stronger than citizenship in delineating the sample.

The resulting sample of the larger dataset contains data from 3,783 patients, representing 61.5% of COVID-19-infected Petz Aladár County Teaching Hospital patients. The sample includes data from 1,941 men and 1,842 women. The age distribution of the sample is representative of the total population. Thirteen percent were under 40, 22.7% were between 41 and 60, and 64.3% were over 60. Two thousand five hundred ninety people went home after treatment, whereas 1,193 died in the hospital. As for the comorbidities highlighted in the study, diabetes affected 5.9%, hypertension 37.7%, and diabetes and hypertension together 11.8% of the patients, representing the rates observed for the overall population. Of the sample studied, 0.5% were included in the first wave, 27.3% in the second wave, 37.1% in the third wave, 18.6% in the fourth wave, and 16.6% in the fifth wave. The distribution by the waves is not significantly different from the overall population distribution. About a quarter—24.7%—of patients were registered in 2020, 57.1% in 2021 and 18.2% in 2022. Regarding the sample's spatial distribution (Table 1), the Győr district is dominant, with 67.4%, while the Csorna district stands out with 10.5%. Patients from the districts of Kapuvár, Mosonmagyaróvár, Pannonhalma, Sopron, and Tét are almost equally represented in the sample.

Table 1 Spatial distribution of the sample, n = 3,783

Districts	Frequency (persons)	Relative frequency	Cumulative relative frequency
Csorna	397	10.5%	10.5%
Győr	2,550	67.4%	77.9%
Kapuvár	131	3.5%	81.4%
Mosonmagyaróvár	224	5.9%	87.3%
Pannonhalma	187	4.9%	92.2%
Sopron	137	3.6%	95.8%
Tét	157	4.2%	100.0%
Total	3,783	100.0%	

Source: Own table based on data from Petz Aladár County Teaching Hospital

A majority of participants lived in either Győr or a town (larger settlement), with a minority living in smaller communities (*villages*) (Table 2).

Table 2 Distribution of the survey sample by settlement category, n = 3,783

Settlement	Frequency (persons)	Relative frequency	Cumulative relative frequency
Győr (county seat)	1,750	46.3%	46.3%
Villages in the sample	1,547	40.9%	87.2%
Towns in the sample without Győr	486	12.8%	100.0%
Total	3,783	100.0%	

Source: Own table based on data from Petz Aladár County Teaching Hospital

Examination of additional sample cross-sections will enable us to explore possible spatial differences in patient statistics and related patterns. Broken down by settlement category and gender, the proportion of men is higher in all three categories (Table 3). The difference in male and female rates is larger, but not significantly so, in the category of villages and county towns than in Győr.

Table 3 Distribution of the sample by settlement category and gender

Settlement	Gender	Frequency (persons)	Relative frequency	Cumulative relative frequency
Győr (county seat)	Men	885	50.6%	50.6%
	Female	865	49.4%	100.0%
	Total	1,750	100.0%	
Villages in the sample	Men	799	51.6%	51.6%
	Female	748	48.4%	100.0%
	Total	1,547	100.0%	
Towns in the sample without Győr	Men	257	52.9%	52.9%
	Female	229	47.1%	100.0%
	Total	486	100.0%	

Source: Own table based on data from Petz Aladár County Teaching Hospital

In all three categories, the share of older age groups is significantly higher by settlement and age group, especially in urban areas (Table 4).

Table 4 Distribution of the sample by settlement category and age group

Category of settlement	Age group	Frequency (persons)	Relative frequency	Cumulative relative frequency
Győr (county seat)	0-40	207	11.8%	11.8%
	41-60	376	21.5%	33.3%
	≥ 61	1,167	66.7%	100.0%
	Total	1,750	100.0%	
Villages in the sample	0-40	220	14.2%	14.2%
	41-60	383	24.8%	39.0%
	≥ 61	944	61.0%	100.0%
	Total	1,547	100.0%	
Towns in the sample without Győr	0-40	64	13.2%	13.2%
	41-60	101	20.8%	34.0%
	≥ 61	321	66.0%	100.0%
	Total	486	100.0%	

Source: Own table based on data from Petz Aladár County Teaching Hospital

Examining the sample by settlement category and final medical status (Table 5), we found that most people in all three settlement categories survived their hospital experience long enough to be discharged (and presumably recover from their illness), with no significant difference in proportional death rates.

Table 5 Distribution by settlement category and final patient status

Category of settlement	Status	Frequency (persons)	Relative frequency	Cumulative relative frequency
Győr (county seat)	Discharged from the hospital to home	1,203	68.7%	68.7%
	Deceased	547	31.3%	100.0%
	total	1,750	100,0%	
Villages in the sample	Discharged from the hospital to home	1,061	68.6%	68.6%
	Deceased	486	31.4%	100.0%
	Total	1,547	100.0%	
Towns in the sample without Győr	Discharged from the hospital to home	326	67.1%	67.1%
	Deceased	160	32.9%	100.0%
	Total	486	100.0%	

Source: Own table based on data from Petz Aladár County Teaching Hospital

It is also worth examining whether there is a significant difference in the final medical status by age group when the sample is split into three categories of settlements and three age brackets (Table 6). In Győr, men 61 years of age or older saw disproportionately poor outcomes relative to men in other age groups, with only slightly more (293) being discharged than dying (263). A similar pattern was observed for female patients, with older women being far more likely than younger women to die. Similar age-related differences were observed for villages and towns. Among those who died, there was a significantly higher proportion of people aged 61 years of age and over. The distributions suggest that age influences mortality, but no significant spatial differences can be found.

Table 6 Distribution by settlement category and final patient status

Settlement category	Gender	Status	Age group	Frequency (persons)	Relative frequency	Cumulative relative frequency
Győr (county seat)	Male	Discharged from the hospital to home	0-40	79	13.7%	13.7%
			41-60	203	35.3%	49.0%
			≥ 61	293	51.0%	100.0%
			Total	575	100.0%	
		Deceased	0-40	3	1.0%	1.0%
			41-60	44	14.2%	15.2%
			≥ 61	263	84.8%	100.0%
			Total	310	100.0%	
	Female	Discharged from the hospital to home	0-40	122	19.4%	19.4%
			41-60	120	19.1%	38.5%
			≥ 61	386	61.5%	100.0%
			Total	628	100.0%	
		Deceased	0-40	3	1.3%	1.3%
			41-60	9	3.8%	5.1%
			≥ 61	225	94.9%	100.0%
			Total	237	100.0%	
Villages in the sample	Male	Discharged from the hospital to home	0-40	88	16.2%	16.2%
			41-60	196	36.0%	52.2%
			≥ 61	260	47.8%	100.0%
			Total	544	100.0%	
		Deceased	0-40	3	1.2 %	1.2 %
			41-60	43	16.9 %	18.0%
			≥ 61	209	82.0 %	100.0 %
			Total	255	100.0 %	
	Female	Discharged from the hospital to home	0-40	128	24.8 %	24.8 %
			41-60	124	24.0 %	48.7 %
			≥ 61	265	51.3 %	100.0 %
			Total	517	100.0 %	
		Deceased	0-40	1	0.4 %	0.4 %
			41-60	20	8.7 %	9.1 %
			≥ 61	210	90.9 %	100.0 %
			Total	231	100.0 %	

Towns in the sample without Győr	Male	Discharged from the hospital to home	0-40	23	14.9 %	14.9 %
			41-60	55	35.7 %	50.6 %
			≥ 61	76	49.4 %	100.0 %
			Total	154	100.0 %	
		Deceased	0-40	1	1.0 %	1.0 %
			41-60	14	13.6 %	14.6 %
			≥ 61	88	85.4 %	100.0 %
			Total	103	100.0 %	
	Female	Discharged from the hospital to home	0-40	40	23.3 %	23.3 %
			41-60	30	17.4 %	40.7%
			≥ 61	102	59.3 %	100.0%
			Total	172	100.0 %	
		Deceased	41-60	2	3.5 %	3.5%
			≥ 61	55	96.5%	100.0%
			Total	57	100.0%	

Source: Own table based on data from Petz Aladár County Teaching Hospital

Patient age, the number of comorbidities, and the potential mortality impact of certain diseases, such as diabetes and hypertension, should also be examined on smaller cross-sectional datasets, as this would provide an opportunity to show possible regional differences.

2.3. RESULTS OF MULTIVARIATE ANALYSES

2.3.1. SPATIAL AND GENDER DIFFERENCES IN THE SURVIVAL OF COVID-INFECTED PEOPLE—THE EFFECT OF AGE

As age increases, comorbidities increase, and a person's health often steadily declines. The emergence and rapid spread of new, unknown pathogens negatively impact older people's life expectancy. This disparate impact on older adults is generally true and a natural product of weaknesses in an ageing immune system. Even so, examining gender-specific outcome differences by region are worthwhile so that future researchers and policymakers may work to identify and help vulnerable groups.

The association between age and patient survival was examined using binary logistic regression (binary logistic model) (Table 7). We began by using our univariate model to explain the effect of age on the patient's life expectancy for men and women and to determine whether there are differences in the statistics for Győr, the county's cities, and the county's non-urban municipalities.

The model is significant for male patients living in Győr, improving the random classification by 5.8%. Their age explains 24.3% of the variance in the patient's survival and 7.6% of the chance of correctly categorizing their survival. For female patients, the model is also significant, improving the odds of predicting patient outcomes by only 0.1% compared to random classification. Their age explains 23.1% of the variance in the patient's survival and 7% in the chance of correctly categorizing their survival.

The model is significant for hospitalized male patients from the villages of the county, with a 4.2% improvement in random classification. Their age explains 22.5% of the variance in the patient's survival and improves the chance of correctly categorizing their survival by 6.7%. The model improves the random classification by only 2.6% for female patients. Their age explains 29.1% of the variance in the patient's survival. Knowing the patient's age improves the chance of correctly categorizing his/her survival by 7.1%.

The model is significant for hospitalized men from the towns in the county, with a 10.9% improvement in random classification. Their age explains 26.7% of the variance in the patient's survival and improves the chance of correctly categorizing their survival by 7.5%. For women, the model improves the random classification by only 3.9%. Their age explains 39.4% of the variance in the patient's survival. Knowing the patient's age improves the chance of correctly categorizing his/her survival by 11.8%.

Age positively correlates with the probability of death, but the explanatory power and predictive power of age are low. For the samples studied, age as a classifier is a better determiner for women, has higher explanatory power, and the correct classification rate is also higher for women. No significant spatial differences can be found.

Table 7 The impact of age on the patient's survival by gender in the different territorial units

Subset of sample	n	Model sig.	Correct class. rate (random)	Const. Wald	Nagelkerke R^2	Correct class. rate (model)	Age Wald	Exp (B)
Males (Győr)	885	0.000	65%	76.874 (sig.: 0.000)	0.243	70.8%	119.41 (sig.: 0.000)	1.071
Females (Győr)	865	0.000	72.6%	163.395 (sig.: 0.000)	0.231	72.7%	93.962 (sig.: 0.000)	1.07
Males (villages)	799	0.000	68.1%	99.671 (sig.: 0.000)	0.225	72.3%	97.185 (sig.: 0.000)	1.067
Females (villages)	748	0.000	69.1%	103.626 (sig.: 0.000)	0.291	71.7%	109.019 (sig.: 0.000)	1.071
Males (towns)	257	0.000	59.9%	9.985 (sig.: 0.002)	0.267	70.8%	38.574 (sig.: 0.000)	1.075
Females (towns)	229	0.000	75.1%	52.222 (sig.: 0.002)	0.394	79%	35.413 (sig.: 0.000)	1.118

Source: Own table based on data from Petz Aladár County Teaching Hospital

2.3.2. SPATIAL AND GENDER DIFFERENCES IN THE OUTCOME OF COVID INFECTIONS—THE IMPACT OF THE NUMBER OF COMORBIDITIES

The model is significant for male patients from Győr and cannot be used to improve the random classification (Table 8). The number of reported comorbidities explains 1.5% of the variance in the patient's survival. The model is significant for female patients but adding it cannot improve the random classification. The number of reported comorbidities explains 6.3% of the variance in the patient's survival.

The model is significant for male patients from the villages and cannot be used to improve the random classification. The number of recorded comorbidities explains 5.1% of the variance in the patient's survival. The model is significant for female patients, and the random classification cannot be improved. However, the number of recorded comorbidities explains 10.1% of the variance in the patient's survival.

The model is significant for male patients from the county's towns but cannot be used to improve the random classification. The number of recorded comorbidities explains 4.2% of the variance in the patient's survival. The model is also significant for female patients but cannot be used to improve the random classification. However, the number of recorded comorbidities explains 7.6% of the variance in the patient's survival. This seems to be somewhat of a contradiction. The model is statistically significant but practically meaningless, yet it can be used to explain 7.6% of the variance in patients' survival.

The effect of comorbidities was not significant, and the available data do not show that an increase in the number of comorbidities increases the probability of death. This number's explanatory power and predictive power are lower than those of age. For the samples examined, the number of comorbidities as a classifier behaves better for women, has a higher explanatory power and the correct classification rate is higher for women. No significant spatial differences can be found based on the available data. However, the results should be interpreted with care. Although our sample is large, further research is needed. Knowledge of the full list of concomitant diseases, the list of drugs used in treatment, dosage, and biometric and physical parameters of the patients is essential, and it would add further value to the conclusions.

Table 8 The impact of the number of comorbidities on the patient's survival by gender and by different territorial units

Subset of sample	n	Model sig.	Correct class. rate (random)	Const. Wald	Nagelkerke R^2	Correct class. rate (model)	Age Wald	Exp (B)
Males (Győr)	885	0.002	65%	76.874 (sig.: 0.000)	0.015	65%	9.316 (sig.: 0.002)	1.196
Females (Győr)	865	0.000	72.6%	163.395 (sig.: 0.000)	0.063	72.6%	32.653 (sig.: 0.000)	1.566
Males (villages)	799	0.000	68.1%	99.671 (sig.: 0.000)	0.051	72.3%	27.025 (sig.: 0.000)	1.453

Females (villages)	748	0.000	69.1%	103.626 (sig.: 0.000)	0.101	69.1%	45.668 (sig.: 0.000)	1.768
Males (towns)	257	0.004	59.9%	9.985 (sig.: 0.002)	0.043	59.9%	7.754 (sig.: 0.005)	1.358
Females (towns)	229	0.000	75.1%	52.222 (sig.: 0.002)	0.076	75.1%	9.401 (sig.: 0.002)	1.775

Source: Own table based on data from Petz Aladár County Teaching Hospital

2.3.3. SPATIAL AND GENDER DIFFERENCES IN THE SURVIVAL OF PATIENTS WITH COVID—THE COMBINED EFFECT OF AGE AND THE NUMBER OF COMORBIDITIES

One way forward is to examine the age and the number of comorbidities together. The Pearson correlation coefficient of the two variables is 0.487, so it is possible to use them together as explanatory variables.

For men from Győr, the model is significant, with the random classification improving by 6.3% when the two variables are combined. The two variables together explain 24.8% of the variance in the patient's survival (Table 9). Age as a variable increased the ability to classify, improving the probability of correct classification by 7.6% in the bivariate model, all other things being equal. The model is significant for female patients, with no improvement in random classification. The variance of the patient's survival is explained by the two variables together in 23.1%. This percentage is slightly lower than for male patients. The explanatory and classificatory power of age are also more significant for women.

The model is significant for men from the villages of the county, with a 4.2% improvement compared to the random classification. The classification effect of age is more significant than for men. The model is also significant for women, with only a 2.8% improvement in random classification. For female patients from villages, the number of comorbidities increases the chance of correct classification more than age. For women, age and number of comorbidities together explain the variance of the dependent variable better.

The model is significant for men from the towns of the county, with a 10.4% improvement in random classification. For men from county towns, including age in the model increases the probability of successfully classifying a patient's outcome more than the number of comorbidities. The model is also significant for women, improving the random classification by 3.9%. The two variables together explain 39.5% of the variance in the patient's survival.

Using both variables slightly improved the chances of correct classification compared to using age as the single explanatory variable. For both men and women, age is the more significant explanatory variable. No significant gender or regional differences were found.

Table 9 The combined effect of the number of comorbidities and age on the patient's survival by gender, categorized by the different territorial units

Subset of sample	n	Model sig.	Correct class. rate (random)	Nagelkerke R squared	Correct class. rate (model)	Explanatory variables	Wald	Exp (B)
Males (Győr)	885	0.000	65%	0.248	71.3%	Age	117.166 (sig.: 0.002)	1.076
						Number of comorbidities	3.978 (sig.: 0.046)	0.871
Females (Győr)	865	0.000	72.6%	0.231	72.7%	Age	80.466 (sig.: 0.005)	1.07
						Number of comorbidities	0.005 (sig.: 0.994)	0.832
Males (villages)	799	0.000	68.1%	0.225	72.3%	Age	83.101 (sig.: 0.000)	1.067
						Number of comorbidities	0.0886 (sig.: 0.046)	0.998
Females (villages)	748	0.000	69.1%	0.294	71.9%	Age	86.584 (sig.: 0.005)	1.068
						Number of comorbidities	1.808 (sig.: 0.994)	1.138
Males (towns)	257	0.002	59.9%	0.268	70.4%	Age	34.540 (sig.: 0.000)	1.073
						Number of comorbidities	0.138 (sig.: 0.710)	1.047
Females (towns)	229	0.002	75.1%	0.395	79%	Age	33.267 (sig.: 0.000)	1.118
						Number of comorbidities	0.26 (sig.: 0.873)	1.036

Source: own calculation based on data from Petz Aladár County Teaching Hospital

2.3.4. HOW DOES THE NUMBER OF DAYS ON THE VENTILATOR IMPROVE THE ABILITY TO CLASSIFY?

Having assessed the relationship between survival and the already examined variables, we are left with the question of the extent to which the number of days spent on a ventilator contributes to correctly assessing the patient's survival. The variables are not correlated with the age of the patient and the number of concomitant diseases, with Pearson's correlation coefficients of -0.010 and -0.103, respectively. Therefore, their combined use as explanatory variables is not burdened by the problem of multicollinearity.

Using the three variables together significantly increased the Nagelkerke R squared value of the model, as running the model on the six subsamples resulted in at least a 20% increase in explained variance (Table 10). Thus, the number of days spent on the ventilator significantly improves the model's explanatory power. Nevertheless, among the three variables, for all six subsamples, using the patient's age as a variable increases the probability of correctly classifying the patient's survival.

Table 10 The impact of the number of days spent on the ventilator on the model's classification ability

Subset of sample	n	Model sig.	Correct class. rate (random)	Nagel-kerke R squared	Correct class. rate ()	Explanatory variables	Wald
Males (Győr)	885	0.000	65%	0.581	81.4%	Age	117.166 (sig.: 0.002)
						Number of comorbidities	3.978 (sig.: 0.046)
						Number of days on the ventilator	0.001 (sig.: 0.976)
Females (Győr)	865	0.000	72.6%	0.453	77.8%	Age	117.166 (sig.: 0.002)
						Number of comorbidities	3.978 (sig.: 0.046)
						Number of days on the ventilator	0.001 (sig.: 0.976)
Males (villages)	799	0.000	68.1	0.532	78.6%	Age	88.467 (sig.: 0.000)
						Number of comorbidities	6.467 (sig.: 0.00)
						Number of days on the ventilator	24.781 (sig.: 0.11)
Females (villages)	748	0.000	69.1%	0.502	81.4%	Age	84.249 (sig.: 0.000)
						Number of comorbidities	0.01 (sig.: 0.982)
						Number of days on the ventilator	0.001 (sig.: 0.982)
Males (towns)	257	0.000	59.9	0.546	79.4%	Age	27.428 (sig.: 0.000)
						Number of comorbidities	5.789 (sig.: 0.016)
						Number of days on the ventilator	0.000 (sig.: 0.989)
Females (towns)	229	0.000	75.1%	0.562	83.8%	Age	32.519 (sig.: 0.000)
						Number of comorbidities	2.1 (sig.: 0.147)
						Number of days on the ventilator	0.000 (sig.: 0.995

Source: own calculation based on data from Petz Aladár County Teaching Hospital

The combination of the three variables improved the classification ability of the model. The proportion of cases correctly classified by the model is higher for men in the sample of the patients from Győr and for women in the villages and other county towns. At the same time, the improvement was higher for men compared to random classification.

Overall, it can be seen that age was the most important determinant of the survival of patients, with an increase in the mortality gap. No significant regional or gender differences were found. Including the number of days spent on a ventilator significantly improves the model's explanatory power. Age and the number of concomitant diseases significantly explain the variance in the patient's survival, improving the classification's accuracy.

Analysis of the available data confirmed that age, an increase in the number of comorbidities, and an increase in the number of days on a ventilator together increase the risk of death. However, no significant gender or regional differences were found. The effect is slightly stronger for men.

3. CONCLUSIONS

In this study, based on national and international research and guided by the intention to contribute to previous findings, we investigated the effects on COVID-19 outcomes of age, number of comorbidities, and number of days on a ventilator, disaggregated by gender and by territorial units. We focused on Győr-Moson-Sopron County, based on Petz Aladár County Teaching Hospital data.

Age increases the probability of death. Its explanatory and predictive powers are low as a classification factor; it behaves more like age for women. No significant spatial differentiation can be found.

The effect of comorbidities was not significant, and the available data do not show that an increase in comorbidity would increase the probability of death. Its explanatory power and predictive ability are significantly lower than that of age. As a classification factor, it behaves better for women than men, similarly to the patient's age. No significant regional differences can be found based on the available data.

Using both variables together slightly improved the chances of classification compared to using age as a single explanatory variable. For both men and women, age was the more significant explanatory variable. No significant gender and spatial differences were found in the bivariate case.

The number of days spent on a ventilator was included in the classification model in the third stage, which has no linear relationship with age and the number of concomitant diseases. The combination of the three variables improved the classification ability of the model. The proportion of cases correctly classified using the model with the three explanatory variables is higher for men in the Győr sample and higher for women in the villages or other towns in the county. At the same time, the improvement is greater for men compared to random classification.

Our studies so far show that age was the most important determinant of the survival of COVID-19-infected patients, with an increase in the probability of death. No significant regional or gender differences were found. The number of days spent on the ventilator, age, and comorbidities significantly improved the model's explanatory power. Using age and the number of comorbidities significantly explains the variance in the patient's survival, improving the classification accuracy.

The present research contributes to a greater public understanding of COVID-19 outcomes. We hope to build on our results later and determine morbidity and mortality variation across the different pandemic waves. Additionally, we intend to conduct a deeper analysis of the links between socioeconomic development and the impact of certain comorbidities (some already addressed in the literature) and patient survival and recovery.

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