SOCIAL AND ECONOMIC FACTORS SHAPING BETWEEN-COUNTRY INEQUALITIES IN EXCESS MORTALITY DURING THE CONSECUTIVE WAVES OF COVID-19: A EUROPEAN PERSPECTIVE

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ABSTRACT

The COVID-19 pandemic has had a profound but disproportionate impact on countries worldwide, with some experiencing tragically high levels of mortality. This raises the question of whether this outcome was the result of simple inappropriate use of the classic and new pandemic management tools or other factors such as health status or political orientation. To shed light on this issue, our study examines the drivers of excess mortality due to COVID-19 across European countries. Applying the technique of elastic net regression, we found that both markers of neoliberal and illiberal political orientations had an impact on pandemic outcomes, although their importance varied during the second and third waves of the pandemic. Furthermore, excess mortality was negatively associated with life expectancy and GDP. The intensity of the usage of pandemic management tools was mostly associated with the macro-level characteristics of the countries, with only a few having independent effects on excess mortality.

Keywords: COVID-19 excess mortality, non-pharmaceutical interventions, vaccination, illiberalism, neoliberalism

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INTRODUCTION

The health burden of the COVID-19 pandemic has been largely unequal across countries. To quantify and understand the nature of these inequalities has become a central issue and had already been the subject of many studies in a number of research areas. Epidemiologists, sociologists, demographers, as well as political scientists and anthropologists were all seeking to understand the sources of the disproportional effects of the pandemic.

To quantify the COVID-19-related health burden, international comparisons have been applied to a series of measurement tools, such as infection rates, hospitalization rates, COVID mortality rates (Charron et al., 2022; Hamidi et al., 2020), excess mortality rates, and derived measures such as life years lost (Aburto et al., 2022; Pifarré i Arolas et al., 2021). Many of these measurements were proven to be dependent on factors not strictly connected to the actual number of illnesses in a country (Liang et al., 2020). Mortality measures seem to be more objective than those quantifying infections or hospitalization. Among mortality measures, COVID-19-related mortality rates and excess mortality rates provide alternatives for measuring the overall death burden of the pandemic. But, since the beginning, there were major diagnostic differences across countries recording deaths as COVID-19-related. Some countries did so only if tests confirmed the presence of infection. Others relied on the broader definition provided by the World Health Organization (2020), according to which "any death resulting from a clinically compatible illness resulting from a probable or confirmed diagnosis of COVID-19, unless there is a clear alternative cause of death that cannot be related to COVID-19 disease (e.g., trauma)". The decision on the presence of a "clear alternative" obviously has sizeable flexibility. Consequently, there is a large variability in defining if the death was attributable to COVID-19 or not (Beaney et al., 2020; Karanikolos & McKee, 2020; Lau et al., 2021; Marinković & Galjak, 2021). When examining the relationship between reported COVID-19 death and excess mortality, Sanmarchi et al. (2021) found that the deviation between the two depended on the testing capacity: countries with lower testing capacities tended to report fewer deaths attributed to COVID-19 as compared to excess mortality.

Excess mortality, therefore, seems to be a sounder measure of the real health burden of the COVID-19 pandemic than COVID-19-related mortality. Even more importantly, our main interest lies in the overall mortality burden of the pandemic, and not in the causes of these deaths.

Nevertheless, the measure of excess mortality, calculated as a difference between the expected and the actual number (rate) of deaths is not without problems. The procedure of the most commonly used calculation was to take the trend of mortality for the period preceding the outbreak of the COVID-19 pandemic, that is, typically mortality trends experienced in the period between 2015 and 2019. In a European context, this calculation method has some problematic points. In most European countries, mortality did not improve during the above-mentioned period, rather it stalled (Raleigh, 2019). Accordingly, we can expect a mortality improvement for 2020 and the following years in a few countries where mortality had previously declined, e.g., because life expectancy had been improving (most noticeably in Sweden) or had been stagnating or marginally improving in the majority of the European countries. This makes excess mortality a somewhat biased measurement when comparing countries with different baseline trends.

Another potential "unfairness" can occur when using excess mortality as a percentage. By doing so, we would assume that the overall mortality connected to the pandemic should be proportional to general mortality, which is more a research question or hypothesis than a fact that can be taken for granted. Not sharing this assumption from the outset, in this study, excess mortality will be considered in absolute terms.

Over and above, excess mortality can be calculated in a number of different ways, depending on our preferences regarding the comparison baseline. For instance, we can remove the aftermath of "natural disasters" from the baseline, such as heat waves, flooding or influenza outbreaks, but this method is also problematic since such disasters may or may not have occurred in the previous years and can have a significant impact on a given year's mortality rates (Németh et al., 2021; Shkolnikov et al., 2022). Even taking the rates of previous years as they occurred, calculating rates by week or by month may change the results to some extent (Nepomuceno et al., 2022). Levitt and colleagues (2022) compared six different ways of calculating excess mortality, and found rather substantial differences. Notwithstanding the different numerical results of the estimations, the patterns of excess mortality were very similar for those countries included in this current investigation.

The inclusion of countries into our study was based on the nature of the pandemic they have experienced. Most epidemics appear in waves, but the temporal spread of the epidemic by location makes different waves in different places partially incomparable. As experienced during the consecutive waves of the COVID-19 epidemic, time played an essential role in the management of the pandemic, as new pieces of evidence were constantly emerging on the usefulness of tools to mitigate the effects of the epidemic. The availability of pandemic management tools, most importantly screening and vaccination, were very different during the consecutive waves of the pandemic. Therefore, while searching for determinants of inequalities, we also have to consider the role of possible determinants by waves. This approach reduces the set of countries eligible for inclusion. In European countries, as we will demonstrate later, the consecutive waves of the pandemic appeared close enough to each other in time to qualify for inclusion. In countries on the edge of Europe, like Russia, pandemic waves were not uniform even across the country. In other continents, the timing of waves was different. The focus of this study, therefore, will be Europe.

With regard to cross-country inequalities, Europe was not exceptional in terms of excess mortality compared to the rest of the world. According to the estimations of Wang and his co-workers (2022), for the years 2020 and 2021 combined, the worst-hit countries – where more than 1 out of every 200 persons died in excess – were Bolivia, Bulgaria, Eswatini, North Macedonia, Lesotho, and Peru (in the order of the magnitude of excess mortality).

Large disparities regarding COVID-19-related excess mortality between European geographic regions had already been described using various approaches (Jabłońska et al., 2021; Murkowski, 2022; Ziakas et al., 2022). Description, however, seldom goes without an attempt at explanation. Several studies explore, among other factors, the role of pandemic management measures (for instance, Philips et al., 2021; Ge et al., 2022). What made these studies possible was the unique circumstance that management measures of the COVID-19 pandemic were recorded with an unprecedented level of accuracy. The Oxford COVID-19 Governmental Response Tracker database (Hale et al., 2021) has been collecting data on non-pharmaceutical interventions (NPIs), testing and vaccination on a weekly or daily basis for most countries of the world. This remarkable effort made it feasible to evaluate the possible effects of these interventions. Management measures applied during the pandemic were linked to infection rates (Steigel et al., 2021), as well as to mortality and other "outcomes" in different studies of the previous two years (for example, Sharma et al., 2021).

Apart from the role of specific interventions that took place in different countries, many sought explanations regarding more profound characteristics of countries. The age structure, the health status of the population and the conditions of the public healthcare system (Bíró et al., 2022; Coccia, 2022; Dzurova & Květoň, 2021; Lupu & Tiganasu, 2022) gained special attention in many investigations.

Another set of studies concentrated on a wide range of possible social and environmental predictors of excess mortality. Yet, the COVID-19 pandemic is novel in the sense that political determinants seem eminent among the numerous determinants of pandemic management. In political science, a large body of literature connected pandemic management to different characteristics of domestic politics and policymaking. Textual accounts of pandemic management during 2020 regarding more than 30 countries are available (Greer et al., 2021), demonstrating a strong association between political systems, traditions, power balances, etc., and outcomes in public health. Some studies that took a more traditional public health point of view also argued that public health outcomes cannot be understood without understanding the "political economy" of the epidemic (McKee et al., 2021).

Yet, most studies in the field of political sciences were motivated by a need to explore certain political phenomena (e.g. Trumpism). Particular studies aimed to connect COVID-19 and its impacts with nationalism (Jenne, 2022; Singh, 2022), neoliberalism (Bryant et al., 2020; Šumonja, 2021), right-wing politics (Mazzoleni & Ivaldi, 2022; Rinaldi & Bekker, 2021), populism (Clark & Patterson, 2021; Dressler & Plagemann, 2022; Moise et al., 2021; Recio-Román et al., 2021), egalitarian democracy (Annaka, 2022; Vadlamannati et al., 2021), or trust in governments (Annaka, 2022; Chen et al., 2021). Some authors, however, argued that politics and policy have to be understood together in order to understand governmental responses to the pandemic. Greer et al. (2020) argue that social policy, regime type (democracy or autocracy), formal political institutions (federalism, presidentalism, etc.) and state capacity to control public health and healthcare provision all have to be taken into account in order to understand specific governmental responses. Some of these articles, for instance, Rinaldi and Bekker (2021), provoked a long chain of commentary and debate in the scientific community. The outcome of the debate is probably best summarized by Felder and colleagues (2021), who warned that focusing on some archetypical popular right-wing leaders or parties and their effects on pandemic management can be misleading. Instead, what needs to be placed in the centre is the broader process of the disintegration of welfare states and the growth of insecurities that accompany this phenomenon.

The disintegration of the welfare state, as a major historical process, is addressed in this study as neoliberalism, while processes related strictly to the political system are addressed as illiberalism, encapsulating the deviation from traditional standards of democracy. That said, the current study only looks at the most important aspect of neoliberalism with regard to public health, namely, the reduction of welfare spending.

Previous studies on country-level determinants made it clear that neither the actual policy measures (interventions) nor political economic characteristics of countries can be ignored when searching for determinants of COVID-19-related deaths.

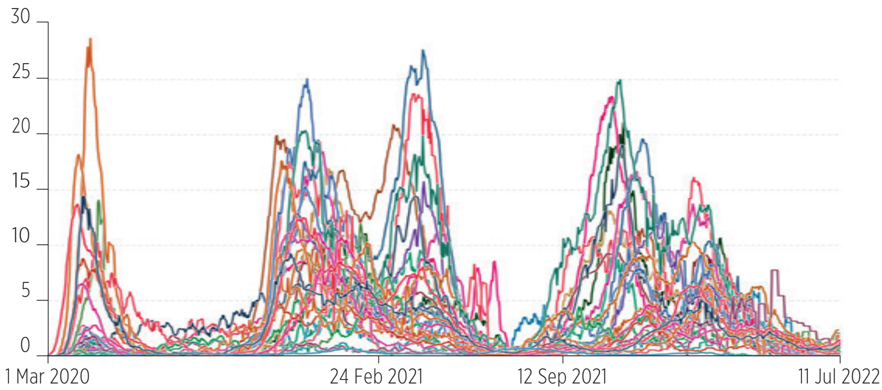
However, the peculiarities of studying this pandemic led to further consequences regarding the possible designs of the study. These considerations reinforce our previous decision that the effects of COVID-19 can be better understood by separating the individual waves. The demographic profile of excess mortality was different in each wave (Tóth, 2022; Urbine et al., 2020). More importantly, knowledge of the disease, tools for fighting against it, public awareness, as well as the entire economic and social context in which disease management took place, was also different during consecutive waves of the pandemic. Studies on the effects of NPIs often applied time frames broken down by waves of the pandemic (Ge et al., 2022; Sharma et al., 2021), while this or similar approaches were not common when exploring the effects of possible social and economic determinants of COVID-related deaths. Therefore, we aim at filling this gap with this study by considering the effects of these factors wave by wave to explain disparities across European countries.

DATA AND METHODS

When governments or health authorities make decisions about actions during a pandemic, these decisions are most likely based on their perception of risk, the assumed magnitude of the danger. The COVID-19 epidemic is unique in the sense that the perception of risk – at least in Europe – was largely based on daily reported numbers of infections and deaths. The daily reports of the Regional Offices of the World Health Organization (WHO) and the European Centre for Diseases Prevention and Control provided a new tool for countries to assess their position in the pandemic in absolute terms, as well as relative to other countries (Sebhatu et al., 2020). The most impressive, though continuously debated measure was the number of deaths directly attributed to COVID-19 infections, which probably was one of the most important factors influencing countries in choosing and applying policies. Therefore, in order to define "waves", we used COVID-related deaths reported by individual countries. The periodization of a pandemic is far from obvious, yet, is very important in our case. In the midst of rising deaths, governments are busy introducing new measures, while in the periods of diminishment, they are more concerned with the possibility of easing already existing measures than introducing new ones.

For studying the temporal pattern of the reported number of deaths in individual European counties, data was provided by the Our World in Data website (Mathieu et al., 2022) regarding the period between 15 March 2020 and 15 January 2022. The periodization of four subsequent waves provided a common framework for the analysis, allowing that mortality was not significant in some waves in certain countries. In late summer, none of the European countries experienced significant mortality attributed to COVID-19 *(Figure 1)*.

Figure 1: Daily new confirmed COVID-19 death per million people as an illustration of waves of the pandemic



Source: Our World in Data (data source: Johns Hopkins University CSSE COVID-19 data), reproduced under the Creative Commons license CC BY 4.0.
Notes: Seven-day rolling average. Due to varying protocols and challenges in the attribution of the cause of death, the number of confirmed deaths may not accurately represent the true number of deaths caused by COVID-19.

The patterns of mortality attributed to COVID-19 for the period between 31 August 2021 and 31 August 2022 show that most countries experienced bicuspid COVID-19 mortality, seeing their minimum during February or March. Thus, 28 February was chosen as the cut-off point. The United Kingdom and Portugal, however, demonstrated different patterns of COVID-19-attributed mortality, thus these counties were excluded from our analyses.

Therefore, in a European context, we could distinguish four waves between March 2020 and January 2022: 15 March 2020 – 31 August 2020 (first wave), 1 September 2020 – 28 February 2021 (second wave), 1 March 2021 – 31 August 2021 (third wave), and 1 September 2021 – 31 January 2022 (fourth wave).

This periodization proved to be very close to other wave definitions because it was based on observed patterns, but we did not find it directly applicable to all European countries. As it was mentioned, the UK and Portugal were excluded due to the differences in COVID-19 mortality patterns. We also excluded countries with less than 500 000 inhabitants.

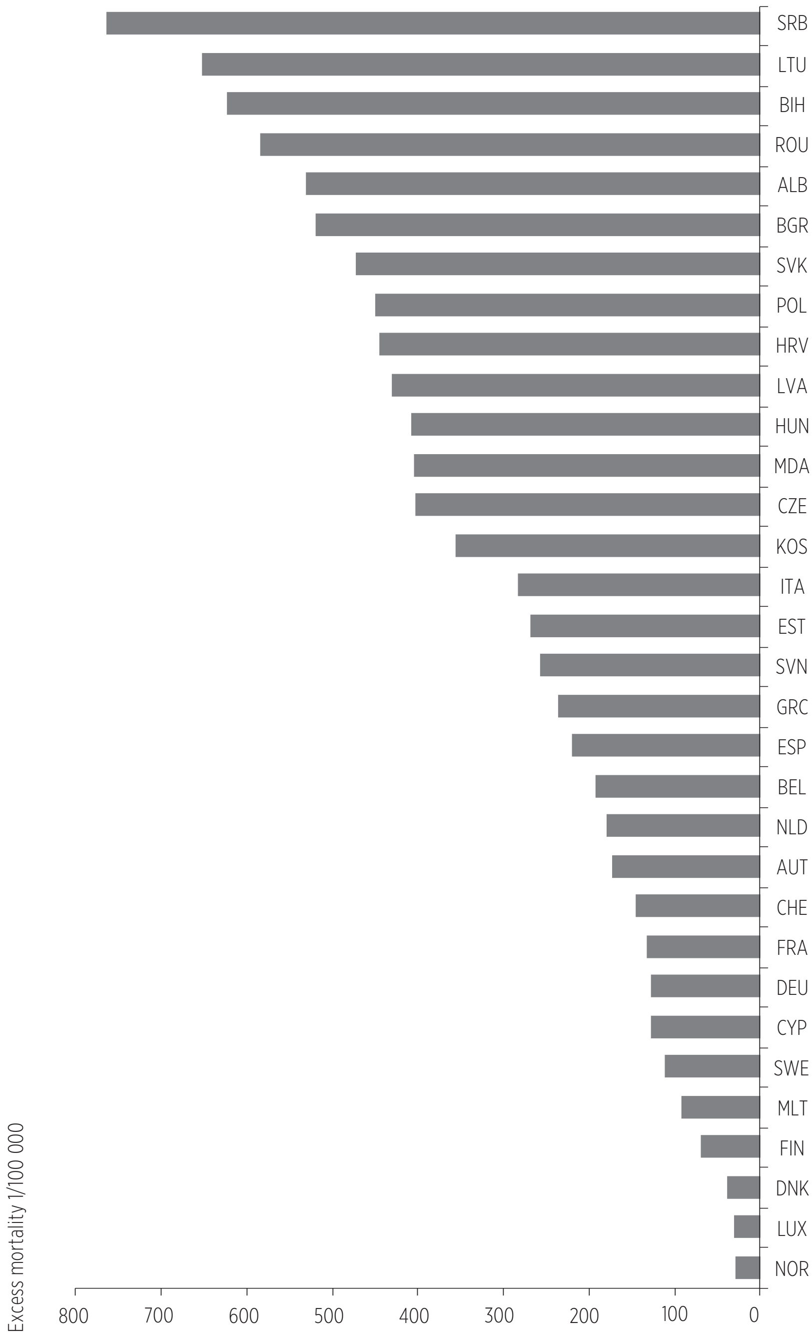
Our outcome variable, excess mortality, was already calculated by different research groups around the world. In this study, we use data provided by Karlinsky and Kobak (2022) because of their monthly availability. Weekly estimates were also available for most countries, based on the difference between observed and predicted mortality. Mortality predictions were based on the mortality figures of the years 2015–2019, applying a dynamic base for 2000, 2001 and 2002.

The provided excess mortality numbers were transformed to a 1/100 000 rate (i.e. crude mortality rate). Age-standardized rates were available only for a limited number of countries from other sources; consequently, we decided to use the crude rates and we tried to control for the age distribution during our analysis.

Figure 2 shows excess mortality for selected European countries. Though data regarding the fourth wave were not complete at the time of writing this article, we included data on the incomplete fourth wave as well to demonstrate the difference in the nature of the pandemic during consecutive waves. While mainly Western European countries were afflicted during the first wave, Central Eastern and Southern Eastern countries proved to be much more vulnerable during the second wave. The third wave left Western Europe mostly unaffected but had a considerable death toll in the rest of Europe. Finally, the pattern of the second wave seems to have returned in the fourth one.

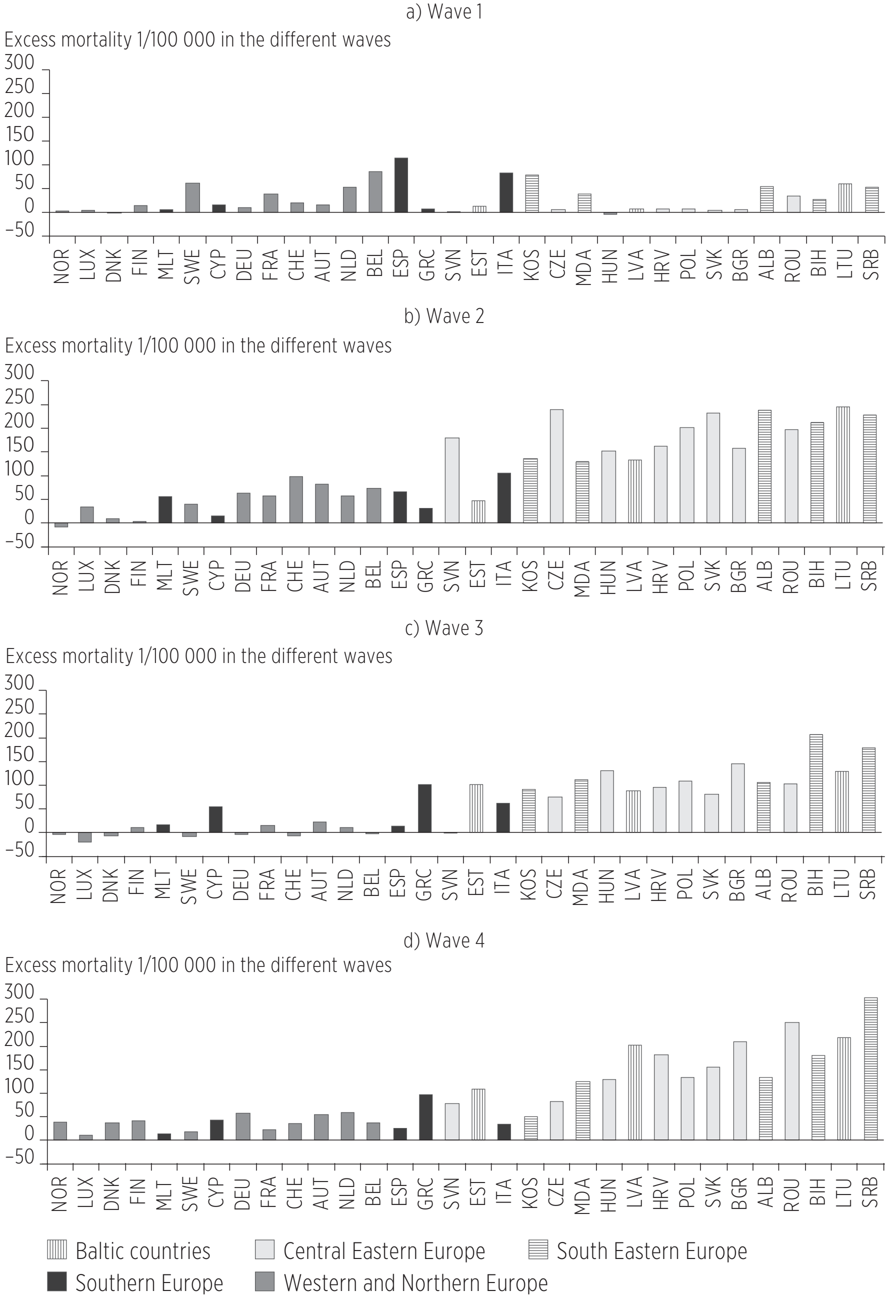
These first results motivated us to change our research question to why Central Eastern and Southern Eastern Europe suffered a proportionally higher pandemic burden in terms of mortality.

Figure 2: Overall excess mortality (1/100 000) during the four subsequent waves between 15 March 2020 and 15 January 2022 in selected European countries



Source: Karlinsky & Kobak, 2022.
Note: See *Table A1* for county codes.

Figure 3: Excess mortality (1/100 000) during COVID-19 in selected European countries by pandemic wave



Source: Karlinsky & Kobak, 2022.
Note: See *Table A1* for county codes.

As for pandemic management, we used all the measures on which the Oxford COVID-19 Governmental Response Tracker (OxCGRT; Hale et al., 2021) collected information. These data have been published (and continuously updated) via the Our World in Data website (Mathieu et al., 2022). They do not cover all of the indicators originally developed by the OxCGRT, since only 14 of them proved to have the most significant impact on everyday life.

The literature on the effects of the pandemic is vast and some studies have yielded contradictory results. A comprehensive review analysing the impact of gathering and movement restrictions, face covering, restrictions on international travel, public transport, and workplace and school closures found significant effects regarding the transmissions of the infection, with the extent of these effects varying by wave (Ge et al., 2022). The vast impact of face covering was proved for the first wave in the United States (Chernozhukov et al., 2021). The effectiveness of contract tracing as a classical tool of public health has never been questioned and was proven again during the COVID-19 pandemic (see for instance Fetzer & Graeber, 2021). We have less evidence regarding vaccination policy since COVID-19 vaccines are relatively new and their effects cannot yet be fully evaluated. Nevertheless, recent studies support the inclusion of this variable in our analyses (Chen, 2023).

The pandemic management indicators considered for inclusion are listed in *Table 1*.

Additional policy measures included debt relief, a measure that recorded whether the government is freezing financial obligations (e.g. stopping loan repayments, preventing services like water from stopping or banning evictions) (Hale et al., 2021). This measure seemed to be primarily aimed at private households, not enterprises. The coding of the debt relief variable was 0 (no debt relief), 1 (narrow relief, specific to one kind of contract) and 2 (broad debt/contract relief).

A similar measure included in the OxCGRT was income support. This, though intended to measure income supplement for individuals or families, in many cases was channelled through employers. The applicability of this measure for our purpose, therefore, is questionable.

Table 1: Pandemic management indicators and coding

Indicators	Scoring
School closure	0 – No measures 1 – Recommend closing 2 – Require closing (only some levels or categories) 3 – Require closing all levels
Workplace closure	0 – No measures 1 – Recommend closing (or work from home) 2 – Require closing (or work from home) for some sectors or categories of workers 3 – Require closing (or work from home) for all but essential workplaces
Cancellation of public events	0 – No measures 1 – Recommend cancelling 2 – Require cancelling
Restrictions on gatherings	0 – No restrictions 1 – Restrictions on very large gatherings (the limit is above 1,000 people) 2 – Restrictions on gatherings between 101–1,000 people 3 – Restrictions on gatherings between 11–100 people 4 – Restrictions on gatherings of 10 people or less
Closure of public transport	0 – No measures 1 – Recommend closing (or significantly reduce volume/route/means of transport available) 2 – Require closing (or prohibit most citizens from using it)
Public information campaigns	0 – No COVID-19 public information campaign 1 – Public officials urging caution about COVID-19 2 – Coordinated public information campaign (e.g. across traditional and social media)
Staying at home	0 – No measures 1 – Recommend not leaving house 2 – Requires not leaving house with exceptions for daily exercise, grocery shopping, and 'essential' trips 3 – Requires not leaving house with minimal exceptions (e.g. allowed to leave only once every few days, or only one person can leave at a time, etc.)
Restrictions on internal movement	0 – No measures 1 – Recommend movement restriction 2 – Restrict movement
International travel controls	0 – No measures 1 – Screening 2 – Quarantine arrivals from high-risk regions 3 – Ban on high-risk regions 4 – Total border closure
Testing policy	0 – No testing policy 1 – Only those who both (a) have symptoms AND (b) meet specific criteria (e.g. key workers, admitted to hospital, came into contact with a known case, returned from overseas) 2 – Testing of anyone showing COVID-19 symptoms 3 – Open public testing available to asymptomatic people

Table 1: Pandemic management indicators and coding (continued)

Indicators	Scoring
Contract tracing	0 – No contact tracing 1 – Limited contact tracing, not done for all cases 2 – Comprehensive contact tracing, done for all cases
Face coverings	0 – No policy 1 – Recommended 2 – Required in some specified shared/public spaces outside the home with other people present, or some situations when social distancing not possible 3 – Required in all shared/public spaces outside the home with other people present or all situations when social distancing not possible 4 – Required outside the home at all times, regardless of location or presence of other people
Vaccination policy	0 – No availability 1 – Availability for ONE of the following: key workers / clinically vulnerable groups / elderly groups 2 – Availability for TWO of the following: key workers/ clinically vulnerable groups / elderly groups 3 – Availability for ALL the following: key workers / clinically vulnerable groups / elderly groups 4 – Availability for all three, plus partial additional availability (select broad groups/ ages) 5 – Universal availability

Source: Phillips & Tatlow, 2022.

In addition, we included an indicator measuring the daily movement of people, using the Google mobility indicator (Google LLC, 2022), published alongside Policy Response Indicators. The data measure app usage and similar data relative to early 2020. This variable records six broad categories of movement, connected to residency, groceries and pharmacies, workplaces, parks, transit stations, and retail and recreation. In this study, we only used the measure of mobility reduction in visiting workplaces.

Mobility data were not available for Albania, Cyprus and Kosovo. To be able to keep these countries in the analysis, we imputed data. We based our data for Albania and Kosovo on that from Bosnia- Hercegovina. In the case of Cyprus, we used data from Greece as our basis. We will revisit this particular point when discussing the limitations of this study.

All interventions were measured by their average intensity. In this respect, we followed in the footsteps of other studies in this field (Ge et al., 2022), assuming that, for instance, open public testing could prevent more deaths that testing only those who show symptoms of the disease.

Non-pharmaceutical interventions were complemented by two other policy measures. Though testing policy was included in the list of non-pharmaceutical interventions, the amount of testing completed is a fairly independent indicator of how strong the fight against the epidemic was, considered pivotal by many. In this case, the logic behind creating the testing indicator was somewhat different than in the case of other policy measures.

First, we picked a date for each country and wave that indicated the peak of mortality (the highest value of daily COVID-related deaths). We also considered the number of tests administered a month before the mortality peak, accounting for the considerations leading to a broader or narrower provision of tests. Due to the fact that tests were not widely available during the first wave, testing rates (per 1000 inhabitants) were only calculated for the second and the third waves. With the occurrence and diffusion of non-PCR tests ("rapid tests"), the number of which had not been recorded, this factor became somewhat meaningless by the fourth wave. Only the number of tests administered was recorded, but whether or not they were available to the public free of charge is unknown. Testing data for the second and third waves were not available for Kosovo. Based on testing data available for later dates, we imputed half of the value given for Moldova regarding both waves. This point will be readdressed when discussing limitations.

A vaccination indicator (% of people vaccinated) was constructed similarly to the variable on testing but was measurable only with regard to wave 3. In the preliminary phase of the research, we calculated several, highly correlated measures: the percentage of the population that received one dose of vaccine and the percentage fully vaccinated, and these measures were also available for the dates one month prior to the mortality peak. Among these measures, the proportion of people fully vaccinated a month before the mortality peak had the strongest relationship with mortality. Vaccination numbers were not available during the first wave (as there were no vaccines yet fully developed) and were very scarce during the second, thus this variable was only used in the case of the third wave.

Based on results from previous studies, we included several indicators regarding healthcare as background variables: the publicly collected sum of money spent on healthcare per capita, the number of hospital beds (per 100 inhabitants), the number of working medical doctors (per 1000 inhabitants) and the number of nurses (per 1000 inhabitants). During the first stages of the analysis, these indicators proved to be abundant, and only the measure of the number of hospital beds was used in the final analysis.

To measure "neoliberalism", we only used two indicators. One of them is closely related to healthcare, namely, the proportion of GDP spent by the government on healthcare (source of data: WHO, 2022). In addition, aiming to measure social spending, we employed the sum of tax revenue as a percentage of GDP and total social security contributions revenue (collected on the state, local or non-profit organizational level) as a percentage of GDP (source of data: World Bank, 2022). The latter construction is likely to be a more accurate measure of redistribution than if we only would have considered tax-related measures.

The quality of democracy is measured by the indicators developed by the Freedom House (2023). Originally, a higher number of indicators were considered to measure inclusion, however, during preliminary analysis, most of these indicators proved to be highly correlated with each other. The two least correlating indicators, namely, "functioning of the government" and "rule of law" were chosen. The first one ranges from 0 to 12 and the second from 0 to 16, with higher values indicating more democratic functioning. Countries included in the investigations ranged between 4 and 12 regarding the functioning of government and between 6 and 16 regarding the rule of law indicators.

Table 2: Descriptive statistics on the outcome variable and pandemic management variables by wave

	Mean	Standard error of mean	Min.	Max.	25th percentile	50th percentile	75th percentile	N
				Wave 1				
Excess mortality	28.360	5.447	−4.577	113.818	5.257	14.520	52.649	32
School closures	2.172	0.087	1.318	3.000	1.796	2.244	2.446	32
Workplace closures	1.704	0.065	0.835	2.318	1.471	1.850	2.000	32
Cancellation of public events	1.579	0.064	0.824	2.000	1.304	1.591	1.979	32
Stay-at-home orders	0.978	0.081	0.000	2.000	0.579	0.944	1.288	32
Face covering	1.377	0.147	0.000	3.529	0.768	1.471	1.969	32
Public transportation restrictions	0.597	0.079	0.000	1.518	0.340	0.544	0.893	32
Internal movement restrictions	0.908	0.077	0.000	1.959	0.572	0.826	1.257	32
International travel restrictions	2.944	0.114	0.247	3.600	2.860	3.000	3.344	32
Testing policies	1.813	0.085	1.000	2.941	1.501	1.879	2.097	32
Contract tracing	1.467	0.098	0.000	2.000	1.000	1.565	2.000	32
Debt relief intensity	1.349	0.103	0.000	2.000	0.915	1.482	1.879	32
Vaccination policy	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
Reduction in mobility (to work)	−30.443	0.975	−42.193	−22.867	−33.413	−28.713	−26.914	29

Table 2: Descriptive statistics on the outcome variable and pandemic management variables by wave (continued)

	Mean	Standard error of mean	Min.	Max.	25th percentile	50th percentile	75th percentile	N
Wave 2								
Excess mortality	114.589	14.163	−8.599	245.596	48.849	101.112	192.878	32
School closures	1.678	0.072	1.000	2.652	1.300	1.638	1.999	32
Workplace closures	1.844	0.057	1.171	2.519	1.609	1.793	2.097	32
Cancellation of public events	1.686	0.050	0.967	2.000	1.499	1.732	2.000	32
Stay-at-home orders	1.096	0.103	0.000	2.000	0.714	1.240	1.595	32
Face covering	2.823	0.157	0.359	4.000	2.091	2.956	3.558	32
Public transportation restrictions	0.302	0.065	0.000	1.006	0.000	0.099	0.646	32
Internal movement restrictions	0.713	0.115	0.000	2.000	0.000	0.735	1.145	32
International travel restrictions	2.646	0.120	1.000	4.000	2.171	3.000	3.000	32
Testing policies	2.224	0.084	1.000	3.000	2.000	2.000	2.581	32
Contract tracing	1.546	0.088	0.000	2.000	1.044	1.622	2.000	32
Debt relief intensity	0.669	0.039	0.000	1.033	0.637	0.707	0.800	32
Vaccination policy	1.271	0.120	0.000	2.000	1.000	1.188	2.000	32
Reduction in mobility (to work)	−23.899	0.660	−30.423	−13.247	−26.052	−24.597	−21.583	29
Tests per 1000 inhabitants	397.4	81.25	11	2133	159.6	261.6	405.1	32
Wave 3								
Excess mortality	62.855	10.844	−19.124	206.388	2.577	68.573	105.072	32
School closures	1.573	0.073	0.614	2.196	1.247	1.592	2.000	32
Workplace closures	1.745	0.075	1.060	2.630	1.391	1.739	2.000	32
Cancellation of public events	1.495	0.058	1.000	2.000	1.181	1.503	1.776	32
Stay-at-home orders	0.955	0.100	0.000	2.000	0.546	0.948	1.333	32
Face covering	2.663	0.112	1.228	3.663	2.000	2.769	3.182	32
Public transportation restrictions	0.381	0.075	0.000	1.321	0.000	0.147	0.810	32
Internal movement restrictions	0.493	0.087	0.000	1.859	0.000	0.462	0.799	32
International travel restrictions	2.444	0.119	0.897	3.266	2.033	2.658	3.000	32
Testing policies	2.559	0.077	1.707	3.000	2.115	2.747	2.985	32
Contract tracing	1.452	0.092	0.000	2.000	1.000	1.470	2.000	32
Debt relief intensity	3.782	0.120	2.245	5.000	3.448	3.818	4.323	32
Vaccination policy	1.099	0.117	0.000	2.000	0.770	1.003	1.802	32
Reduction in mobility (to work)	−20.123	0.651	−27.074	−13.294	−22.635	−20.491	−17.210	29
Tests per 1000 inhabitants	908	179.1	60	4400	385.9	619.8	848.8	32
Vaccination per 100 inhabitants	14.5	1.687	0.6	32.8	4.27	16.15	20.85	32

Source: Hale et al., 2021; Karlinsky & Kobak, 2022; Mathieu et al., 2022; the author’s calculations.

The datasets regarding all waves contained non-normally distributed variables that were highly correlated with each other. Commonly used regression techniques proved not to be adequate in this scenario. One possible remedy to the problem is the use of a Lasso or robust regression, both of which have already been used by others analysing the effects of pandemic management (Bosancianu et al., 2000; Chatterjee et al., 2021; Elliot et al., 2021; Sousa et al., 2020).

A robust regression was applied because of the highly correlated nature of the independent variables, while a Lasso regression was applied because of the high number of independent variables relative to the sample size. The combination of the two methods creates the elastic net regression. In this study, therefore, we used an elastic net regression (Friedman et al., 2010), which has also been used by others exploring predictors of COVID-19 mortality (Bryan et al., 2021; McCoy et al., 2021). The results are cross-validated, using 1000 samples.

During the several steps of estimation, the initially moderate influence of single predictors can be transformed into other predictors. As a consequence, the results cannot be interpreted as straightforwardly as in the case of traditional regressions.

Table 3: Descriptive statistics of structural variables

	Mean	Standard error of mean	Min.	Max.	25th percentile	50th percentile	75th percentile	N
Wave 1								
% of the population aged 70+	12.9	0.4	5.5	17.1	11.6	13.5	14.3	32
GDP per capita	33 857	3 125	5 190	94 278	23 628	31 908	44 587	32
Hospital beds per 1000	5.0	0.3	2.2	8.0	3.4	4.6	6.4	32
Life expectancy	79.6	0.576	71.9	83.78	77.01	80.94	82.2725	32
Functioning of government	9.53	0.407	4.0	12.0	9.0	10.0	11.0	32
Rule of law	12.6	0.516	6	16	11	13.5	15	32
Healthcare expenditure as % of GDP	8.14	0.372	2.8	11.7	6.616	8.026	10.087	32
Tax + social contribution as % of GDP	26.5	0.908	12.8	34.7	24.6	27.2	30.2	31

Source: Freedom House, 2023; World Bank, 2022; World Health Organization, 2022; the author's calculations.

The provided solutions by SPSS (version 26) are the "optimal" and the "selected" models. The optimal models are the "best explaining" models, e.g. the ones that provide larger "regulation R^2" values, while generally still having a large number of explanatory variables. The "selected models", on the other hand, include fewer variables, are more parsimonious, and their overall explanatory power is reduced compared to the optimal models, but this loss is negligible. In the selected models the most important determinants are more clearly presented. However, none of the coefficients can be interpreted as a metric of "association" of a single determinant, since these incorporate other, smaller effects belonging to other determinants, while being highly correlated with the single determinant in question.

Therefore, the interpretation will be reduced to the fact that a coefficient is non-zero. The sign of the correlation does not change during the Ridge or Lasso transformations, thus that the signs of the coefficients can also be interpreted.

RESULTS

During the first wave, the intensity of workplace closure and stay-at-home regulations were positively associated with mortality. The reduction in visiting workplaces shows a negative association with mortality (i.e., a smaller reduction in visiting workplaces is associated with higher mortality), as expected. More intense workplace closure and stay-at-home measures, however, were associated with higher mortality during the first wave. In this case, we have to keep in mind that the introduction of stricter measures often happened as a reaction to high mortality. However, information on the timing or the intensification of these measures are not taken into account.

Table 4: Regularized (elastic net) regression result: coefficients in the optimal models

	Wave 1	Wave 2	Wave 3
School closure		0.313	
Workplace closure	0.336		
Cancellation of public events			
Stay at home orders	0.481	0.014	
Face covering		0.162	
Public transport restriction		−0.196	
Internal movement restrictions			
International movement restrictions		−0.208	−0.042
Testing policy		−0.078	
Vaccination policy		−0.010	
Contract tracking		0.005	
Debt relief		−0.052	
Mobility reduction (to workplaces)	−0.104	0.112	
Total number of tests performed per 1000		−0.162	
% of people vaccinated	n.a.	n.a.	
% of population aged 70+		−0.078	
Life expectancy		−0.292	−0.283
GDP per capita			−0.216
Hospital beds per 1000		0.139	
Functioning of government		−0.200	−0.078
Rule of law			−0.262
Public expenditure on healthcare as % of GDP		0.001	−0.154
Tax + social contribution as % of GDP		−0.075	
Regularization R^2	0.803	0.905	0.880
Ridge Penalty	0.00	0.50	0.90
Lasso penalty	0.35	0.10	0.60

Source: Freedom House, 2023; Hale et al., 2021; Karlinsky & Kobak, 2022; Mathieu et al., 2022; World Bank, 2022; World Health Organization, 2022; the author's calculations.
Note: Only statistically significant coefficients are reported.

Altogether, our determinants seem to have little to do with the explanation of excess mortality seen in the first wave. None of the structural variables seems to have any role in shaping the outcome, which was likely the result of the fact that other determinants (like international travel intensity) are not included in this study. Altogether, our models are not very strong in explaining the excess mortality during the first wave.

Table 5: Elastic net regression results: coefficients in the most parsimonious models

	Wave 1	Wave 2	Wave 3
School closure		0.173	
Workplace closure	0.167		
Cancellation of public events			
Stay at home orders	0.269		
Face covering		0.061	
Public transport use restrictions		−0.086	
Internal movement restrictions			
International movement restrictions		−0.120	−0.004
Testing policy			
Contract tracking			
Debt relief			
Mobility reduction (to workplaces)	−0.075		
Total number of tests performed per 1000		−0.121	
% of people vaccinated	n.a.	n.a.	
% of population aged 70+			
Life expectancy		−0.257	−0.254
GDP per capita		−0.078	−0.191
Hospital beds per 1000		−0.067	
Functioning of government		−0.170	−0.051
Rule of law		−0.171	−0.232
Public expenditure on healthcare as % of GDP			−0.113
Tax + Social contribution as % of GDP		−0.095	
Regularization “R Square”	0.565	0.841	0.847
Ridge penalty	1.00	1.00	1.00
Lasso penalty	0.90	0.45	0.80

Source: Freedom House, 2023; Hale et al., 2021; Karlinsky & Kobak, 2022; Mathieu et al., 2022; World Bank, 2022; World Health Organization, 2022; the author’s calculations.
Note: Only statistically significant coefficients are reported.

Excess mortality of the second wave, on the other hand, is explained much better by our models. Both optimal and selected versions of the models show a number of associations, both for pandemic management and structural variables. Looking at only the parsimonious models *(Table 4)*, some of the pandemic management indicators are associated with pandemic outcomes as expected: more tests administered and more restrictive regulations regarding the use of public transport and international travel are all associated with fewer death. Some of the variables of pandemic management, though, still seem to be a reaction to increasing mortality, e.g., higher mortality was associated with more intense school closures and stricter face-covering regulations. However, the associations between structural variables and excess mortality became stronger in the second wave. The strongest association can be seen between overall (pre-pandemic) life expectancy and excess mortality (lower life expectancies are associated with higher excess mortality). Also, both democracy indicators and one of the neoliberalism indicators are associated with excess mortality in the expected direction: more democratic countries and those with higher rates of redistribution experienced lower excess mortality. The explanatory power of our models is high regarding this period.

In the third wave, however, indicators of pandemic management lost their explanatory power. Only restrictions on international travel show a moderate association with mortality. Life expectancy remained a strong predictor and was joined by GDP, both showing rather strong associations with excess mortality: higher life expectancy and high GDP were associated with fewer deaths. Similarly, a strong relationship appeared with the "rule of law" democracy variable: the more democratic and unbiased the legal system is, the lower excess mortality is. Associations with neoliberalism indicators are still present in the third wave, e.g., more expenditure on healthcare is associated with less excess mortality.

Altogether, the strength of democracy seems to have a more robust role in waves two and three, but neoliberalism indicators related to social spending are also present. The most remarkable result of our analysis is the shifting explanatory power of variables across the waves, with the growing roles of GDP and the lawful operation of the legal system towards the third wave.

DISCUSSION

Our understanding of social risk factors of COVID-19-related mortality has considerably changed over time. First-wave analyses were usually based on small (and not necessarily well-selected) samples of countries. The accumulation of knowledge and the widening of the perspective rearranged the sets of factors we deem to be influential. Looking back on the first wave, factors like the share of older age population, population density, a larger share of nursing homes in elderly care, overall connectedness to the world's centres in terms of traffic, overall healthcare quality, and the quick implementation of pandemic measures seemed to be the most influential (Buja et al., 2022; Dzúrová & Květoň, 2021). In our analyses, these variables were not included. We could only detect the "induced" effect of pandemic policy measures, which is likely due to the fact that most of the countries included in our analysis were not deeply affected by the first wave of the pandemic. Consequently, our results contain some degree of bias: countries that were hit hard by the first wave of the pandemic, naturally, employed more and stricter pandemic containment measures.

In the second and third waves, however, all European countries were heavily affected. With regards to the second wave, we found a mix of predictors shaping mortality outcomes: both pandemic policy measures and contextual characteristics of the countries seem to be important. Some of the policy measures were still motivated by mortality: we could see more school closures and more intense face-covering mandates in countries with high mortality, where, we suppose, the sequence of events should be discussed in more detail. The importance of certain pandemic policy measures also emerged: restricted public transport use, restrictions on international travel and more testing (and other correlated measures) were associated with lower excess mortality. Stronger democracies, as defined by both of our democracy indicators, were associated with fewer excess deaths, i.e., fewer people died in countries where there was a well-functioning government and where the legal system worked accurately and without bias. These results contradict most of the previous research findings on the relationship between democracy and COVID-19, especially those that were based on data from the first wave of the epidemic (Bosancianu et al., 2020; Engler et al., 2021; Karabut et al., 2021). Conversely, Jain et al. (2022) found that less democratic countries had more COVID-related deaths. Chang et al. (2022) also found democracy, trust in governments and strength of the legal system to be important predictors of COVID-19 deaths for the first and the first half of the second wave. The latter analysis covers a longer time period than the first wave of the pandemic and an initially larger set of countries and their different subsamples, concluding that the nature of the relationship is different for wealthier and poorer countries. While the general argument explaining the "failure" of most democratic countries in responding to the first wave of COVID-19 is that democracy slows down governmental reactions, this reasoning likely does not hold true for the later waves of the pandemic. Another possible (counter) argument to the "democracy vs. effective COVID-19 containment" debate is that this question may be adequate only in a reduced set of countries, where contexts are similar. Our findings suggest that different aspects of democracy played a different role in the consecutive waves of the pandemic, similarly to the finding of Cepaluni et al. (2021).

Our results for the second wave suggest that the role of "illiberalism" and "neoliberalism" are both apparent, though the influence of illiberalism, and especially the aspect related to the functionality of the government was somewhat more influential. Social democratic orientation is associated with fewer deaths, but the strength of association seems weaker than between democracy indicators and excess mortality.

Over time, and especially during the third wave, quantifying the protective effect of vaccination, as well as the issues of barriers to and inequality of vaccination access started to dominate the health predictor discourse. This shift in narrative is also mirrored in the limited literature discussing patterns and predictors in countries with extra high COVID-19 mortality (Reció-Román et al., 2021; Ziakas et al., 2022). In our analysis, surprisingly, vaccination did not appear among the significant predictors of excess mortality in the third wave, which can be the consequence of the very strong influence of the structural variables. Vaccination, however, likely had an effect on excess mortality in the fourth wave, which is not covered by the current analysis.

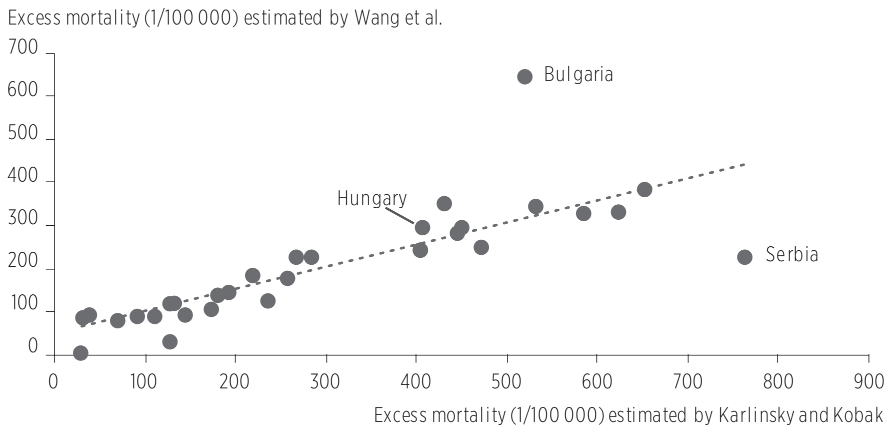
Regarding the third wave, we have found that both the social democratic orientation of a country (indicated by the magnitude of tax revenue relative to GDP) and the strength of democracy played a significant role in determining excess mortality. Analysing a subset of European countries, Bejan and Nikolova (2022) found no relationship between the type of welfare state and the overall outcomes of the pandemic. In contrast, we found some evidence that welfare orientation did in fact matter. This contradiction can be resolved if we consider that on the larger set of countries included in our analysis, more profound differences can be detected regarding the welfare orientation – between Western and South-Eastern Europe, for instance – than differences seen among the Western and Northern European nations.

LIMITATIONS

Including countries that are less frequently represented in international comparisons automatically came with certain limitations. Some data was not available, typically for Albania and Kosovo. Therefore, we performed a sensitivity analysis with a variety of imputed values. The results were largely unchanged.

At the time of writing, there is no scientific agreement on the best way to calculate excess mortality. Several considerations could be taken into account, especially when calculating the "base" mortality, and they lead to different outcomes. To illustrate this point, we compare the excess mortality values used in our study and the values originating from the careful calculations of Wang et al. (2022). As we can see *(Figure 4)*, the estimations of Karlinsky and Kobak are higher than that of Wang, but the results of the estimations are highly correlated, and there is disagreement regarding Bulgaria and Serbia.

Figure 4: Estimated excess mortality from different sources



Source: Karlinsky & Kobak (2021); Wang et al. (2022), the author's compilation.

Another set of limitations is associated with the characterization of non-pharmaceutical interventions (NPIs). In this study, we looked at the interventions in terms of their intensity, while the timing of their implementation was neglected (except for the testing and vaccination variables, to some extent). In reality, the exact timing of the introduction of lockdown or face covering measures is obviously important, but timing may also be essential for measures of capacity to influence infection rates indirectly, such as factors like debt relief. The incorporation of the timing of the introduction of certain NPIs should be definitely accounted for in further research.

Concerning NPIs, we also should keep in mind that the OxCGRT is a new and unique dataset, which was designed to help assess the effectiveness of non-pharmaceutical interventions across countries and regions against the spread of COVID-19 (Altman et al., 2022). These new indicators should be subject to a long series of studies. In this paper, we did not utilize the full potential of the dataset. Again, the exact timing of the introduction of some measures, for instance, was proven to influence the death toll, especially in the first and second waves of the pandemic, as mentioned above (Balmford et al., 2020).

Regarding structural variables, we used values from 2019 in most of the cases (or earlier years if data for 2019 were not available). Democracy indicators from 2019 were also entered into the analyses, though it is known that democratic standards were violated during the pandemic in most countries of the world (Edgell et al., 2021), not to mention the decrease in life expectancy and shrinking of the GDP. Our inquiry was based on the assumption that pandemic responses were rather shaped by the long-term characteristics of countries, like the level of income, state of democracy, etc. than their short-term turbulences. Regarding democratic standards, the magnitude of their short-term violations did not correlate with COVID-19-related death rates (Maerz et al., 2020), however, their changes and effects can also be subject to further research. More importantly, however, several key structural characteristics of countries were not included in this study.

Returning to our central question on the higher vulnerability of Eastern Europe in the COVID-19 pandemic: as it was clearly demonstrated by Rangachev et al. (2022), several explanations emerged. Focusing on high excess mortality in Bulgaria in 2020, Rangachev and co-workers (2022) found that the low capacity of healthcare, high co-morbidity (especially cardiovascular morbidity) and, above all, untimely (delayed) lockdown interventions were the likely causes of the outstandingly high COVID-19-related mortality. Geographical distribution of excess mortality suggested, however, that areas with higher rates of workers employed in manufacturing, which presumably means a higher rate of blue-collar jobs in factory environment, experienced higher COVID-related mortality.

Enciu et al. (2022) compared three waves of COVID-19 mortality in Romania and its neighbouring countries. Focusing on the explanation of Romanian mortality outcomes during the pandemic, the high proportion of out-migrating workers was mentioned regarding the first wave and the high levels of vaccine hesitancy for the third wave. Túri et al. (2022) emphasise the structural problems of Romanian healthcare and health governance as causes of these trends.

Among the indicators of a country's position in the global economic order, factors such as the outmigration of workers, the expansion of manufacturing or the status of labour rights should also be included in future research, as suggested by analyses of COVID-19-related mortality performed in South Eastern European countries.

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APPENDIX

Table A1: Country codes used in Figures 2 and 3

Country code	Country name
ALB	Albania
AUT	Austria
BEL	Belgium
BGR	Bulgaria
BIH	Bosnia and Hercegovina
CHE	Switzerland
CYP	Cyprus
CZE	Czech Republic
DEU	Germany
DNK	Denmark
ESP	Spain
EST	Estonia
FIN	Finland
FRA	France
GRC	Greece
HRV	Croatia
HUN	Hungary
ITA	Italy
KOS	Kosovo
LTU	Lithuania
LUX	Luxembourg
LVA	Latvia
MDA	Moldova
MLT	Malta
NLD	The Netherlands
NOR	Norway
POL	Poland
ROU	Romania
SRB	Serbia
SVK	Slovakia
SVN	Slovenia
SWE	Sweden

Note: Alpha-3 country codes as described in the ISO-3166 international standard, with the exception of Kosovo.