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Mortality and Health Spending during the First Year of the COVID–19 Pandemic. Comparing Central, Eastern and Western Europe

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Abstract

The article shows the relationships between the COVID and non-COVID deaths during the first year of the pandemic, compared with the stringency of restrictions imposed and the compulsory spending on healthcare. We compare these relationships among European countries, analysing weekly data and applying cointegration models. Regarding the pandemic's intensity, we split the period into two: March – August 2020 and September 2020 – February 2021. We find that, most often, if there was a relationship between the stringency index and COVID or non-COVID mortality, it was usually positive and mortality driven. That suggests that although the governments tailored the restrictions to the growing mortality rate, they were unable to control the pandemic. No relationships, or negative ones, were most often found in these countries where the spending on healthcare was the highest (i.e., Northern and Western European countries). The biggest weekly changes in non-COVID deaths during the second sub-period were observed in the Central and Eastern European countries, where government healthcare expenditures per capita are the lowest.

Keywords: COVID mortality, Stringency Index, non-COVID mortality, Johansen test, cointegration, healthcare spending

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Introduction

This paper aims to critically analyse data on COVID and non-COVID mortality together with the stringency of government restrictions applied in 31 European economies from March 2020 to February 2021. Regarding the pandemic's intensity in these countries, we split this period into two: March – end of August 2020 and September 2020 – end of February 2021. We explore data on weekly mortality changes, together with the values of the stringency indices (SI) in the respective economies. We look for long-run relationships between SI versus COVID and non-COVID mortality and try to find lead-lag dependencies. Since our data is non-stationary, we apply cointegration models. We compare these relationships between countries from all regions of Europe and learn from them. Looking for economic factors associated with the relationship between mortality and stringency, we identify health expenditure as a factor that differentiates countries.

The rest of the paper is organised as follows. Section 2 provides a short overview of the current literature on the links between COVID–19 pandemic mortality, stringency, and health spending. Section 3 describes the data used in analyses. Section 4 outlines the model and research questions, while Sections 5 and 6 present the main findings. We end the article with a discussion and conclusions.

Literature review

Sornette et al. (2020) presented a comprehensive study of COVID–19 mortality during the first wave of the pandemic. They classified countries into five groups and identified population age structure as one of the factors driving mortality during the first phase of the pandemic. They also analysed the links between mortality and government restrictions. Their analysis confirmed that higher stringency of the restrictions during the first wave was significantly and negatively correlated with deaths per million during the early stages of the epidemic. Similar conclusions are presented by Fuller et al. (2021). They stated that the effect of the restrictions was visible if they had been introduced immediately. However, some researchers claim that, in total, the restrictions were excessive, led to the destruction of the economy in many industries (Chudik et al. 2020; Mckibbin and Fernando 2020), and caused many social (Saladino, Algeri, and Auriemma 2020), mental and psychiatric problems (Arendt et al. 2020; Le and Nguyen 2021). Due to the national lockdowns and patients' fear of being infected in hospitals, the treatment of diseases other than COVID–19 was significantly delayed. Some even talk about the "lockdown victims" (Walker et al. 2020).

Papers analysing the relationship between COVID-related mortality and healthcare expenditures indicate either a lack of dependence (Blondel and Vranceanu 2020) or a negative relationship (Elola-Somoza et al. 2021) during the first sub-period of the first year of the pandemic. Sornette et al. (2020) also mentioned a positive relationship for Western European countries during the first pandemic wave. Stukalo, Simakhova, and Baltgailis (2022) examined the development of key factors of social economy models during the pandemic and formulated recommendations for the post-pandemic period. The most important ones for Central Europe are health care reform, increasing healthcare spending, and diversifying sources of financing for the social sector (e.g. medicine).

The analysis presented in this paper provides an important contribution to the existing scientific literature. First, we investigate the links between pandemic restrictions and mortality to better understand the consequences of efforts taken by governments during that time. The approach based on cointegration models allows us to examine long-run relationships in non-stationary data time series and name the leading variables. In the second part of the research, we point out links between COVID and non-COVID mortality and the mandatory expenditures on healthcare, which gives a clear signal to state governments.

Data

We analyse weekly changes in COVID mortality, non-COVID mortality and Stringency Index. We collected COVID mortality data and the Stringency Index from the Oxford COVID–19 Government Response Tracker (OxCGRT) database, available freely through GitHub (The COVID Tracking Project 2021; Hale et al. 2021). The data covers the period from March 2020 to February 2021. We split this period into two subperiods: March 2020 – end of August 2020 and September 2020 – end of February 2021. Due to the cyclical nature of the data, we aggregated it to weekly frequency. To get the number of weekly non-COVID deaths, we subtract the number of deaths attributed to COVID–19 from the total deaths per week. We collected the data on total mortality from the Eurostat database (Deaths by week) (Eurostat 2021a). To allow for a suitable comparison across countries, we normalize mortality data for population size to deaths per million population.

The SI is a composite measure built on nine indicators and re-scaled to a value from 0 to 100 (Hale et al. 2021). We use it as a measure of the government's response to the pandemic.

Data on health care expenditures are also important for interpreting our results. Data on compulsory government expenditure on health protection (Government/Compulsory Health spending per capita in USD, the annual average 2016–2019) come from the OECD database (OECD 2022).

In Table 1, we present the minimal and maximal SI values versus weekly changes in COVID and non-COVID deaths per million in two subperiods of the first year of the pandemic, as well as healthcare spending in each analysed country.

The minimal and maximal values of the SI index are presented in Table 1, in columns (1)–(2) and (7)–(8). On average, the countries imposed higher constraints in the first phase, which paradoxically was less severe than the second one. In the first phase, the most extreme restrictions were imposed in Serbia (100 points), Croatia (96.30), Cyprus (94.44), and Italy (93.52), while the mildest were in Iceland (53.70), Norway (54.69), and Sweden (64.81). In the second phase, the SI did not exceed 90 in any analysed country, reaching a maximum of 88.89 in Greece, 87.04 in Slovenia, and 85.19 in Germany. Interestingly, Croatia, with one of the highest restrictions, belonged to the group with the lowest SIs in the second period. Serbia also changed its restrictions policy drastically. The countries with the mildest policy in the first phase did not change it in the second.

The minimal and maximal values of weekly changes in COVID deaths (per million people) are displayed in Table 1, in columns (3)–(4) and (9)–(10).

In the first subperiod, the highest maximum was present in a relatively small Belgium (183.09 per million inhabitants). However, as researchers said, it was more like a result of too hastily qualifying many deaths from other diseases as COVID deaths (Stein 2020). The second-highest number was reached by Spain (120.97 per million), followed by France (104.15), the United Kingdom (96.75), and Italy (92.75). We note that the numbers represent weekly changes in the deaths classified as COVID-related, and we can interpret them as the speed of the pandemic spread. These maxima are much lower in Central and Eastern Europe (CEE); the lowest maximal weekly changes of COVID deaths in the first subperiod of the pandemic were 2.12 (Latvia) and 2.20 (Slovakia).

In the second period, the situation changed completely, and the maximal values were higher. The highest maximal values of weekly changes in COVID deaths were observed in CEE, i.e. 178.94 (Slovenia) and 139.31 (Bulgaria). Overall, in 7 of the 12 CEE countries, the maximum exceeded 100 per million citizens. In countries with the highest maxima in the first period (Belgium, Spain, France, Italy, and the United Kingdom), mortality declined in the second period, which may indicate that the epidemic developed more slowly there. The lowest maxima were observed in Northern European countries (except Sweden).

Finally, in columns (5)–(6) and (11)–(12) in Table 1, we present the analogous data for weekly changes in non-COVID deaths. In the first period, the maxima of the weekly changes of non-COVID deaths (per million inhabitants) are quite similar in all countries.

Comparing the maxima of the changes in the first and second subperiods, in some economies, the numbers are not too different. However, in some, the number of non-COVID deaths almost doubled or grew even more. They were mostly CEE countries, e.g. Bulgaria

(311 versus 684), Czechia (217 versus 395.46), and Poland (222 versus 429), among others. In other regions, the respective numbers did not change significantly, e.g. in Norway (157.71 versus 159) or Belgium (371.97 versus 319.51). Sometimes they even decreased, for instance, in the United Kingdom (363 versus 215) or Spain (445 versus 283). The only exception is Portugal, where non-COVID deaths almost doubled (259 versus 493).

Methods and research questions

Our research concentrates on the relationships between the SI and the mortality behaviour in selected European economies. We look for long-run relationships between SI versus COVID and non-COVID mortality and try to find lead-lag dependencies.

We start by testing the stationarity of our series in two subsamples. We performed the ADF and KPSS cross-tests. Most of the series proved to be non-stationary. However, in many cases, the tests were inconclusive. For the sake of consistency, we do not include the results of the test in the article, but they are available upon request. Therefore, we analyse cointegration relationships between two pairs: SI index versus COVID deaths and SI index versus non-COVID deaths, for all the cases where at least one test (ADF or KPSS) concluded the integration of order 1. We note that the lack of a long-run relationship may be a consequence of the stationarity of some series or their non-standard properties, such as fractional integration (see, e.g. Hassler and Wolters 1994 or Lee and Schmidt 1996 for a discussion).

Thus, we address the following research questions:

- [Question 1] Does a long-run relationship exist between the SI index and COVID deaths? If the restrictions are effective, we should observe a negative long-run relationship between the two and short-term adjustment. Two scenarios are possible: either the mortality adjusts to the index, which suggests the effectiveness of the applied tool, or the SI adapts to the mortality, which implies that the governments observe the mortality rate and adjust their policy accordingly. In both cases, we expect a negative long-run relationship between the two variables.
- [Question 2] Does a long-run relationship exist between SI index and non-COVID deaths? We assume that the restrictions – if imposed wisely – should not affect non-COVID mortality. Such a phenomenon would suggest that either the deaths are not correctly classified or – if the relationship is positive – that the restrictions were too harsh, blocking access to the treatment of other diseases.

Cointegration model

The cointegration model is already a classical one in econometric studies. It was proposed by Engle and Granger (1987). We concentrate on a bivariate case here. If both our variables are integrated of order 1 – i.e. are I(1), we first verify whether we can establish a long-run relationship between them:

$$Deaths_t + \alpha \cdot SI_t + z_t = 0, \tag{1}$$

where $Deaths_t$ denotes a change in the number of COVID or non-COVID deaths per million inhabitants between weeks t and $t-1$, SI_t – the number of deaths related to COVID between weeks t and $t-1$, while z_t denotes the error term. If the series are cointegrated, then z_t should be stationary.

Two alternative specifications of the long-run relation model exist:

- the model with a constant $Deaths_t + \alpha_0 + \alpha \cdot SI_t + z_t = 0$,
- the model with trend $Deaths_t + \alpha \cdot SI_t + \delta t + z_t = 0$.

If the cointegration relationship is present in the data, we estimate the error-correction equation (further: ECM), i.e.:

$$\begin{aligned} \Delta\, Deaths_t &= \psi_0 + \gamma_1 \hat{z}_{t-1} + \sum_{i=1}^{K} \psi_{1,i} \Delta SI_{t-i} - \sum_{i=1}^{L} \psi_{2,i} \Delta\, Deaths_{t-1} + \varepsilon_{1,t} \\ \Delta SI_t &= \phi_0 + \gamma_2 \hat{z}_{t-1} + \sum_{i=1}^{K} \phi_{1,i} \Delta Deaths_{t-i} - \sum_{i=1}^{L} \phi_{2,i} \Delta SI_{t-i} + \varepsilon_{2,t} \end{aligned} \tag{2}$$

where $\widehat{z_t}$ is the error term from the regression in Eq. (1) and $\varepsilon_{i,t}$ denotes a white noise process.

The ECM in the first equation states that the changes in mortality are explained by their history, lagged changes in the COVID mortality or stringency index, and the error from the long-run equilibrium in the previous period. The value of the coefficient γ_1 determines the speed of adjustment and should always be negative – otherwise, the system would diverge from its long-run equilibrium path (Pfaff 2008). In our case, it would denote the explosion of mortality.

The second equation can be interpreted as an analysis of the countries' policies. If γ_2 is significant and negative, denoting that the countries responded adequately to the changes in mortality. A positive coefficient would indicate that the restrictions were too severe or long-lasting.

Moreover, if two series are cointegrated, there should be Granger-causation in at least one direction (throughout this paper, we will conclude that one variable leads or lags another). The latter implies that at least one of the error terms should enter equations (2) significantly and with the correct sign (Pfaff 2008).

The Johansen procedure

To investigate the co-integration relationship, we apply the Johansen trace test (Johansen 1991). Let us re-write equation (2) into the vector error correction (VECM) form:

$$\begin{bmatrix} \Delta Deaths_t \\ \Delta SI_t \end{bmatrix} = \begin{bmatrix} \psi_0 \\ \phi_0 \end{bmatrix} + \Pi \begin{bmatrix} \text{Deaths } s_{t-1} \\ SI_{t-1} \end{bmatrix} + \sum_{i=1}^{K} \Gamma_i \begin{bmatrix} \Delta Deaths_{t-i} \\ \Delta SI_{t-i} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{bmatrix}. \quad (3)$$

If both the $Deaths_t$ and SI_t variables are integrated of order 1, then the matrix Π has rank $0 \neq r \neq K$, where $K = n$ is the number of variables in the system (in our case, $K = 2$) and r is the number of cointegrating relations. Thus, the following alternatives are possible:

- $r = 0$: no cointegrating relationships between the I(1) variables;
- $r = K$: all variables are stationary;
- $r < K$ (in our case $r = 1$) – then the matrix Π can be expressed as a product of two matrices $\boldsymbol{\alpha\beta}'$, where both matrices are of order $r \times K$ of rank r .

After establishing the long-run relationship, we investigated the lead-lag dependencies between the variables. We do it based on the values and significance of parameters γ_i ($i \in \{1,2\}$) in equation (2). As already mentioned, if the correction occurs, at least one of the parameters should be negative and significant.

Results

Relationships between the stringency index and COVID deaths

Table 2 presents the results of the tests for the long-run relationships between COVID mortality and the SI index. We show the cases where the Johansen test indicated a long-run relationship (at 5% significance) and where at least one of the error-correcting coefficients was significant and had the correct sign. Therefore, we can indicate which variable was the leading one.

We present the estimates of the vector α, normalised to the Deaths variable. We are interested in the cases where the relationship between the variables was negative ($\alpha_{SI} > 0$), suggesting a decrease in mortality together with an increase in restrictions. We determine the direction of causality based on the short-term adjustment coefficients from the system of error correction equations (Eq. 4). We conclude that SI led mortality when γ_2 is negative and significant. If γ_1 is negative and significant, mortality led SI. The latter denotes the reaction of governments to the death rate. If both coefficients are negative and significant, this implies causality in both directions.

Based on Table 2, we can infer that in the first period, there were only four cases (France, Denmark, the Netherlands, and Portugal) when the SI led the mortality and the increases in the SI and the decreases in the COVID-mortality occurred together. In Luxembourg, the SI also led mortality, but increases in SI and mortality occurred together. SI as a leading variable means that mortality responded to restrictions.

Relationships in both directions appeared in Hungary (negative) and Germany (positive). In all other cases, COVID mortality led the SI, and the relationships were positive (Belgium, Croatia, Iceland). Alternatively, we found no long-run relationship, meaning the restrictions followed an increase in mortality.

In the second subperiod, the negative relationship between SI and deaths was present in Iceland, Portugal, Belgium, Malta, and Switzerland. In Croatia, Germany, and Denmark, the increase in SI co-occurred with the rise in mortality. In half of the cases, SI adjusted to the COVID mortality. However, the reverse was not true, suggesting that although governments tailored the restrictions to the growing mortality rate, they were unable to control the pandemic. In Iceland and Switzerland, the relationships were mutual and led to a decrease in mortality.

Relationships between the stringency index and non-COVID deaths

As mentioned in the introduction, in many countries, severely limited access to medical treatment was a side-effect of the restrictions. Therefore, in some economies, there was an increase in non-COVID deaths, which was an indirect consequence of the restrictions. Therefore, in the second step of the research, we investigate the relationships between SI and non-COVID deaths. The research was designed analogously to the previous investigation. The results are presented in Table 3.

The results are even more complex. Starting with the first sub-period and concentrating on the equation with trends, in all the cases where the Johansen test indicated a long-run relationship between the SI and the changes in non-COVID deaths, the trend was upward in the first phase (Portugal, Romania, Serbia, Germany, Italy, and Norway), apart from Slovenia (a downward trend). Additionally, the relationship between SI and mortality was positive, even if the trend was downward-sloping, suggesting that even without any restrictions, the mortality rate would grow. The positive relationship between the SI and the changes in non-COVID deaths can also be observed for the other six countries (Bulgaria, Greece, Belgium, Finland, Iceland, and Luxembourg) (equation with constant).

There are two countries where the relationships were negative in the first phase, Romania and Slovakia. The changes in SI preceded the changes in non-COVID mortality in both economies. In each case, the test indicated relationships with a constant (relatively high for both). The constant is interpreted as the average week-by-week change in non-COVID mortality. It means that the average weekly change in non-COVID mortality was still very high in these countries. For example, in Romania, it was 279 deaths per million population per week, and each increase in the SI by 1 point reduced this number by 36 people per 10,000. Most often, the changes in mortality preceded the changes in SI, except for Romania, Slovakia, and Serbia.

Table 1. Healthcare spending per capita in USD, minimal and maximal values of weekly changes of SI (values from 0 to 100), COVID and non-COVID deaths per million in two subperiods

Country	Government Health spending	First sub-period 1.03.2020–31.08.2020						Second sub-period 1.09.2020–28.02.2021					
		SI		COVID deaths		non-COV deaths		SI		COVID deaths		non-COV deaths	
		min	max	min	max	min	max	min	max	min	max	min	max
Norway	5,312	35.94	54.69	0.00	9.22	122.11	157.71	34.11	65.26	0.00	7.93	131.15	159.00
Germany	5,192	42.13	76.85	0.25	20.76	192.97	246.60	49.54	85.19	0.35	73.19	199.73	304.34
Switzerland	4,692	35.19	73.15	0.23	44.83	127.33	217.11	29.17	60.19	0.23	77.76	134.84	255.70
Sweden	4,596	35.19	64.81	– 0.10	72.48	147.14	254.37	55.56	69.44	– 0.10	91.49	149.81	235.07
Netherlands	4,411	39.81	79.63	– 0.53	61.98	147.54	296.76	48.15	82.41	0.82	43.01	156.99	237.94
Denmark	4,369	50.93	72.22	0.00	19.51	162.98	199.58	39.81	70.37	0.52	36.95	161.94	219.78
Luxembourg	4,339	23.15	79.63	0.00	36.74	97.45	185.31	44.44	80.56	0.00	92.66	110.23	214.07
France	4,280	46.30	87.96	0.78	104.15	157.49	291.83	43.98	78.70	1.39	62.09	167.10	243.19
Austria	4,087	35.19	81.48	0.11	15.66	153.56	203.86	36.11	82.41	1.11	99.04	169.10	283.13
Belgium	3,859	50.00	81.48	– 8.54	183.09	146.60	371.97	45.37	65.74	1.29	123.82	157.47	319.51
Iceland	3,561	39.81	53.70	0.00	11.72	82.05	175.83	37.96	52.78	0.00	20.51	102.57	164.11
Finland	3,306	32.41	67.59	– 0.18	13.90	170.19	212.97	32.41	55.09	0.00	8.12	168.21	217.12
United Kingdom	3,254	22.22	79.63	127.33	96.75	146.23	363.24	60.19	76.85	1.15	50.07	132.65	215.43
Italy	2,556	50.93	93.52	0.66	92.75	177.10	387.96	49.07	84.26	1.16	83.61	184.89	312.38
Czechia	2,513	34.72	82.41	0.00	6.82	179.20	217.01	38.89	81.48	1.49	131.67	190.59	395.46
Malta	2,441	31.48	87.04	0.00	6.79	106.44	235.54	42.59	52.78	4.53	54.35	140.42	258.19
Spain	2,394	41.20	85.19	– 14.14	120.97	144.20	445.07	60.65	78.70	8.77	69.64	169.10	283.03
Slovenia	2,145	39.81	89.81	0.00	10.10	157.77	212.61	47.22	87.04	0.00	178.94	169.80	383.37

Country	Government Health spending	First sub-period 1.03.2020–31.08.2020						Second sub-period 1.09.2020–28.02.2021					
		SI		COVID deaths		non-COV deaths		SI		COVID deaths		non-COV deaths	
		min	max	min	max	min	max	min	max	min	max	min	max
Portugal	1,874	37.96	82.41	0.10	21.77	183.20	259.89	56.94	80.56	2.16	196.63	185.26	493.49
Slovakia	1,726	29.63	75.00	0.00	2.20	164.66	217.41	28.70	73.15	0.18	131.33	176.39	383.72
Estonia	1,707	32.41	77.78	−4.52	12.82	199.01	257.06	32.41	55.56	0.00	39.20	193.74	304.55
Lithuania	1,561	25.93	81.48	0.00	3.67	253.10	301.22	28.70	76.85	0.00	117.55	247.22	512.44
Croatia	1,515	35.19	96.30	0.00	4.87	206.56	273.06	28.70	50.93	3.90	133.97	226.54	435.05
Poland	1,469	36.11	83.33	0.13	5.15	193.12	222.21	23.15	75.00	2.06	91.58	199.67	429.18
Hungary	1,450	49.07	76.85	0.00	9.42	214.38	289.95	40.74	72.22	1.04	126.81	229.81	431.14
Greece	1,361	40.74	84.26	0.00	3.07	188.14	260.38	50.46	88.89	1.82	67.35	205.70	320.06
Romania	1,246	38.89	87.04	0.00	16.32	236.93	289.02	43.52	76.85	13.88	60.14	216.03	446.99
Cyprus	1,084	47.22	94.44	0.00	4.14	73.71	152.40	50.00	84.26	0.00	19.05	78.68	139.97
Latvia	1,039	41.67	69.44	0.00	2.12	240.17	308.56	32.41	60.19	0.00	84.83	252.36	443.22
Bulgaria	1,021	36.11	73.15	0.14	10.07	258.91	311.00	35.19	54.63	4.46	139.31	265.38	684.04
Serbia	N/A	25.93	100	0	10.07	154.28	264.95	51.85	60.19	0.69	46.92	141.69	456.54

Source: own calculations based on the data from OxCGRT – Eurostat 2021b; Hale et al. 2021; OECD 2022 databases.

Table 2. SI versus COVID deaths – results of the Johansen test

Country	α_{si}	α_{COV}	const.	trend	γ_1	p-value	γ_2	p-value	leading
First sub-period 1.03.2020–31.08.2020									
Croatia	– 0.28	1	x	– 0.85	– 0.83	0.00	0.02	0.46	D
Hungary	0.03	1	– 1.98	x	– 0.02	0.03	0.00	0.00	both
Portugal	0.85	1	x	x	– 0.06	0.62	– 0.14	0.00	SI
Portugal	0.84	1	– 58.36	x	– 0.14	0.15	– 0.13	0.00	SI
France	0.06	1	x	1.46	0.02	0.35	– 0.02	0.00	SI
Germany	– 1.29	1	x	x	– 0.61	0.05	– 0.40	0.02	both
Belgium	– 3.87	1	x	x	– 0.42	0.01	1.38	0.00	D
Denmark	0.13	1	x	0.24	– 0.02	0.56	– 0.09	0.00	SI
Iceland	– 0.02	1	0.63	x	– 0.04	0.04	0.01	0.00	D
Iceland	– 0.03	1	x	0.05	– 0.11	0.04	0.02	0.00	D
Luxembourg	– 17.19	1	x	– 35.60	– 0.64	0.36	– 0.66	0.03	SI
Netherlands	1.02	1	x	3.78	– 0.04	0.79	– 0.57	0.00	SI
Second sub-period 1.09.2020–28.02.2021									
Croatia	– 19.46	1	x	14.01	– 0.22	0.34	– 3.22	0.00	SI
Portugal	0.85	1	x	– 5.98	– 0.02	0.61	– 0.41	0.00	SI
Germany	– 10.80	1	x	16.13	– 3.67	0.02	– 1.37	0.63	D
Malta	3.53	1	x	x	– 0.10	0.01	– 0.06	0.89	D
Malta	4.74	1	– 282.02	x	– 0.12	0.00	0.05	0.90	D
Belgium	171.49	1	– 9973.79	x	– 0.32	0.28	– 2.89	0.00	SI
Denmark	– 1.04	1	x	x	– 1.52	0.00	– 0.02	0.94	D
Denmark	– 1.02	1	44.14	x	– 2.10	0.00	– 0.58	0.24	D
Denmark	– 1.07	1	x	0.05	– 1.51	0.00	– 0.04	0.89	D
Iceland	0.38	1	– 20.46	x	– 0.11	0.01	– 0.28	0.00	both
Switzerland	2.94	1	x	x	– 0.21	0.05	– 0.55	0.01	both

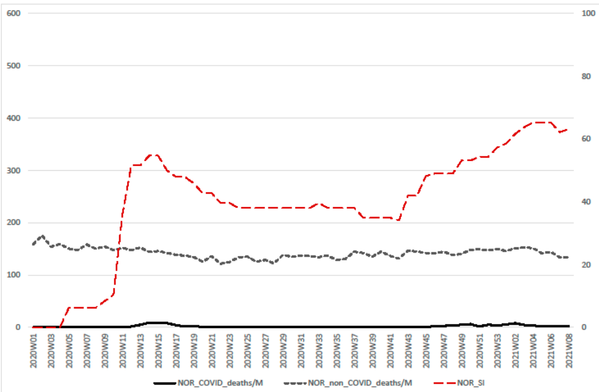
Note: In the last column D denotes that the mortality preceded the changes in SI, while SI – that the changes of restrictions preceded the mortality
Source: own calculations.

Table 3. SI versus non-COVID deaths – results of the Johansen test

Country	α_{si}	α_{nCOV}	const	trend	γ_1	p-val	γ_2	p-val	leading
First sub-period 1.03.2020–31.08.2020									
Bulgaria	−0.17	1	x	x	−0.08	0.02	0.11	0.34	D
Bulgaria	−0.17	1	−279.84	x	−0.06	0.01	0.09	0.19	D
Greece	−0.25	1	−208.75	x	−0.10	0.00	0.18	0.03	D
Portugal	−3.85	1	x	x	−0.82	0.00	0.27	0.51	D
Portugal	−11.76	1	x	−10.18	−0.96	0.00	−0.01	0.97	D
Romania	−4.29	1	x	x	−0.12	0.06	−0.35	0.03	SI
Romania	0.36	1	−279.16	x	0.01	0.77	−0.31	0.00	SI
Romania	−1.23	1	x	−2.55	−0.43	0.00	−0.56	0.15	D
Serbia	−2.17	1	x	−7.07	−0.25	0.30	−1.37	0.00	SI
Slovakia	0.06	1	−183.81	x	0.004	0.54	−0.03	0.00	SI
Slovenia	−1.02	1	x	x	−0.61	0.02	0.46	0.36	D
Slovenia	−1.03	1	−128.41	x	−0.61	0.01	0.45	0.34	D
Slovenia	−0.40	1	x	0.35	−0.55	0.04	0.84	0.08	D
Germany	−2.05	1	x	x	−0.86	0.00	0.17	0.57	D
Germany	−2.05	1	−83.17	x	−0.86	0.00	0.19	0.50	D
Germany	−2.99	1	x	−1.39	−0.95	0.00	0.08	0.79	D
Italy	−3.32	1	x	x	−0.44	0.01	1.11	0.01	D
Italy	−3.30	1	−8.53	x	−0.43	0.02	1.14	0.01	D
Italy	−4.44	1	x	−2.53	−0.73	0.00	1.34	0.03	D
Belgium	−4.96	1	x	x	−0.44	0.01	1.37	0.07	D
Finland	−0.96	1	−145.39	x	−0.63	0.00	1.93	0.00	D
Iceland	−7.52	1	x	x	−0.60	0.00	−0.69	0.65	D
Luxembourg	−0.98	1	x	x	−0.38	0.02	0.53	0.38	D
Norway	−1.70	1	x	x	−0.48	0.00	0.64	0.14	D
Norway	−1.72	1	−64.97	x	−0.49	0.00	0.58	0.18	D
Norway	−2.47	1	x	−0.95	−0.80	0.00	0.99	0.08	D
Second sub-period 1.09.2020–28.02.2021									
Austria	3.64	1	x	x	−0.18	0.03	−0.11	0.10	D
Croatia	20.99	1	x	x	0.23	0.02	−2.35	0.02	SI
Switzerland	0.37	1	x	x	−0.02	0.15	−0.09	0.00	SI
Cyprus	−1.83	1	25.46	x	−0.83	0.00	−0.85	0.36	D
Denmark	−1.85	1	−88.46	x	−0.58	0.00	−0.31	0.41	D

Country	α_{si}	α_{nCOV}	const	trend	γ_1	p-val	γ_2	p-val	leading
Norway	–0.66	1	–111.67	x	–0.70	0.00	–0.38	0.57	D
Poland	1.09	1	–349.42	x	–0.04	0.17	–0.21	0.00	SI
Slovenia	–5.95	1	166.24	x	–1.73	0.00	–1.16	0.49	D
Cyprus	–3.70	1	x	3.38	–1.56	0.00	0.01	1.00	D
Czechia	–6.35	1	x	5.89	–3.57	0.00	–3.59	0.30	D
Denmark	–1.96	1	x	–0.12	–0.78	0.01	–1.49	0.07	D
Iceland	6.99	1	x	3.99	–0.38	0.01	0.42	0.74	D
Portugal	–1.60	1	x	–8.91	–0.55	0.00	0.50	0.51	D
Serbia	–155.30	1	x	26.46	–0.80	0.14	–45.33	0.03	SI
Slovenia	–4.26	1	x	–19.04	–0.34	0.01	–0.15	0.70	D

Note: In the last column D denotes that the mortality preceded the changes in SI, while SI means that the changes in restrictions preceded the mortality
Source: own calculations.



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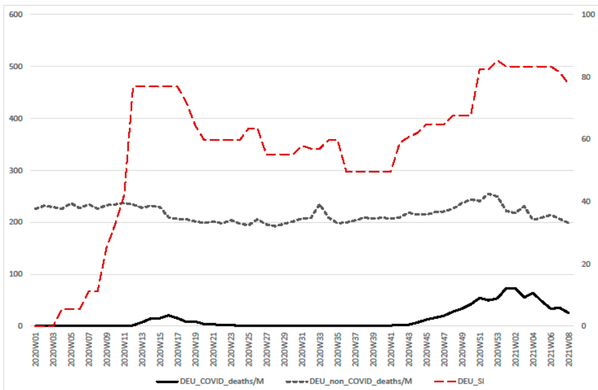

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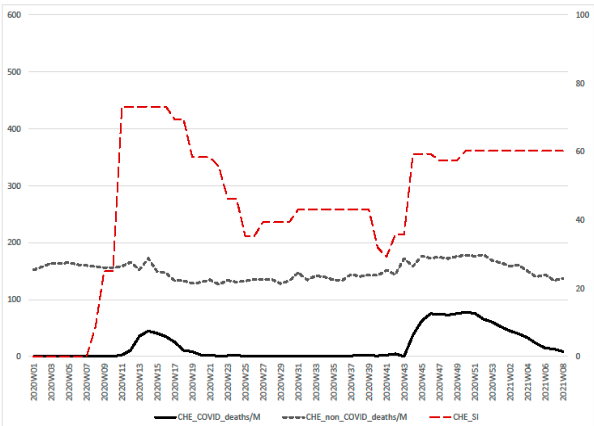

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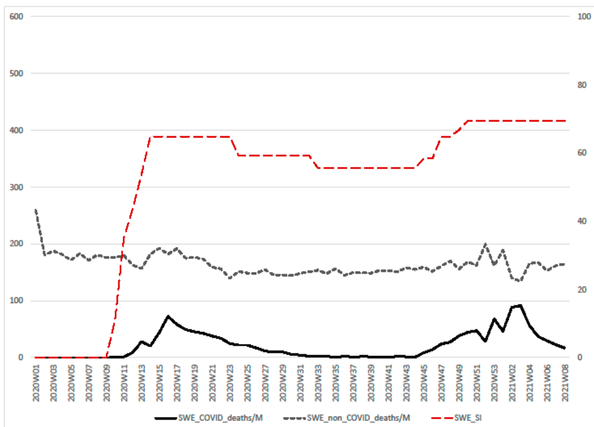

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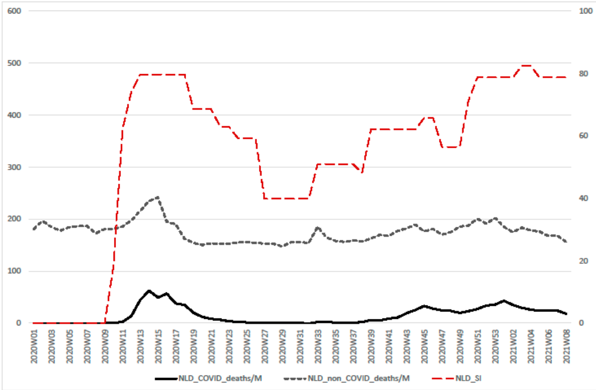

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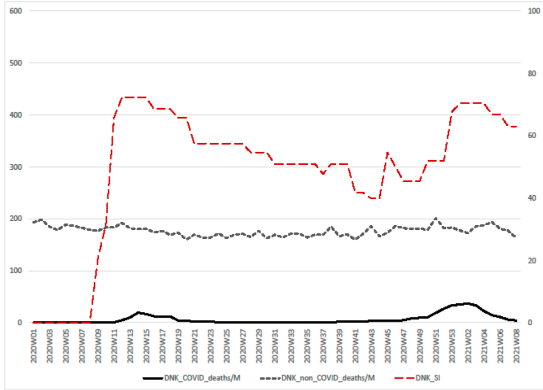

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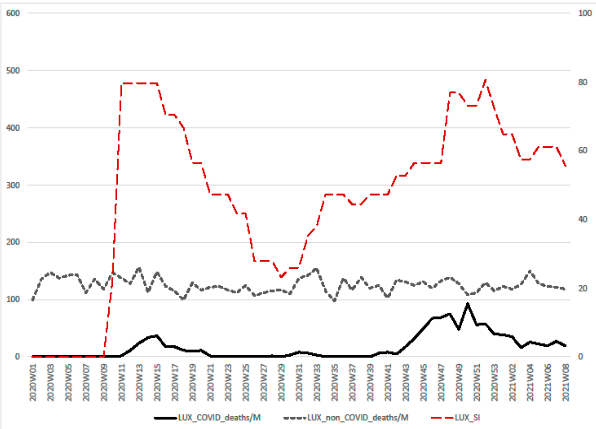

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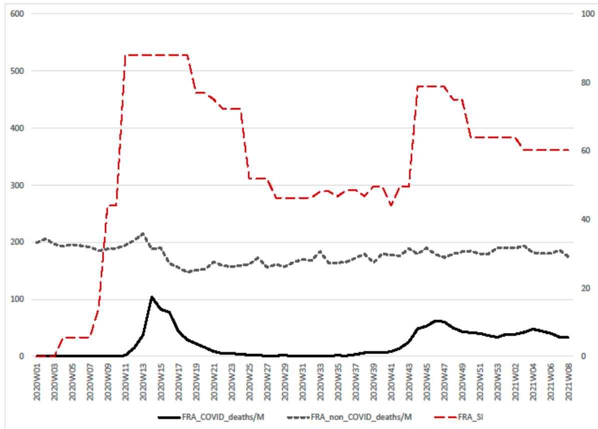

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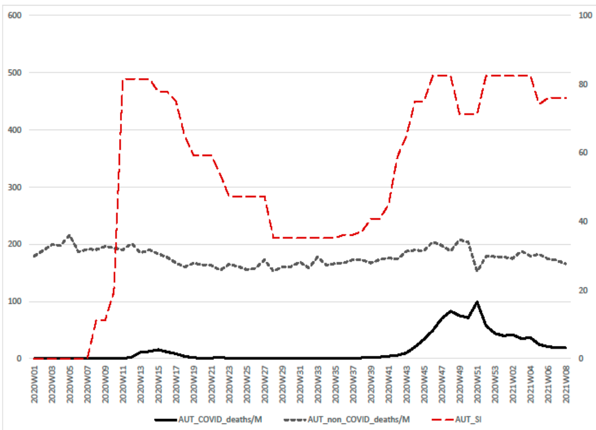

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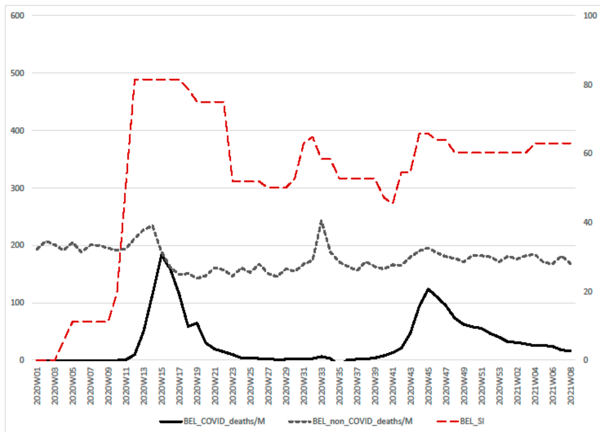

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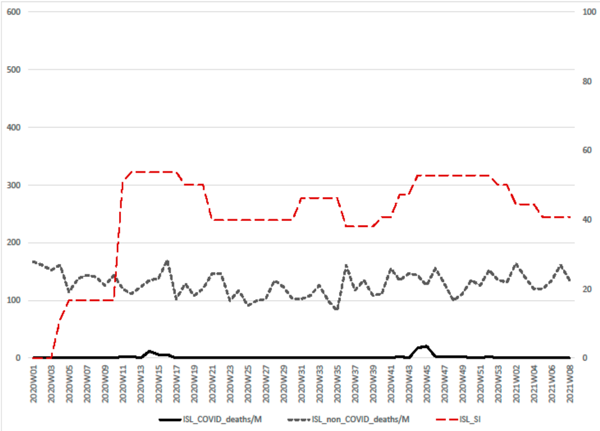

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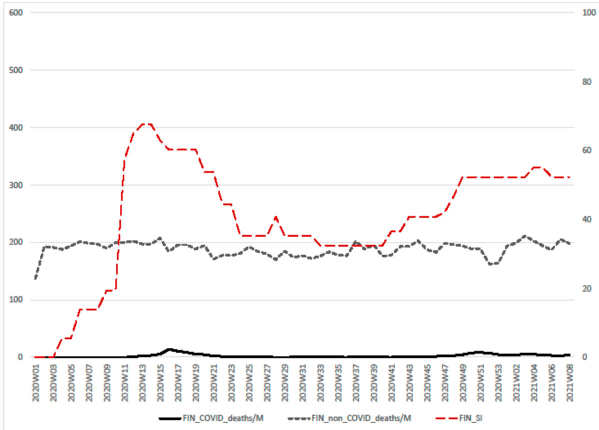

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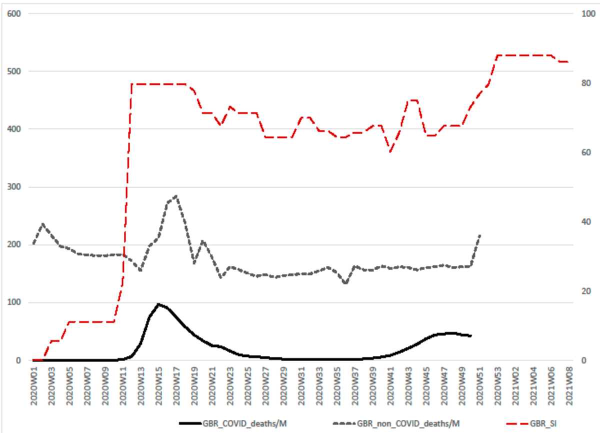

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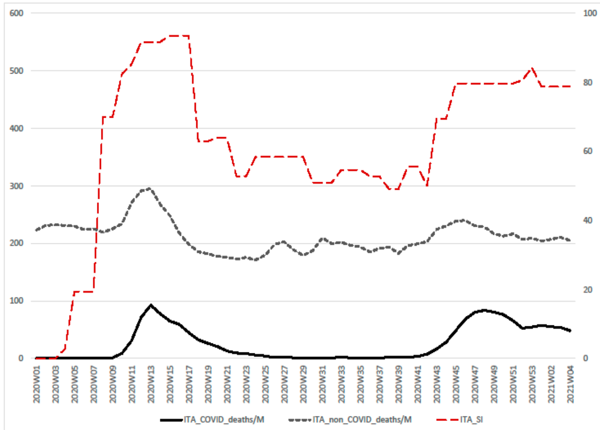

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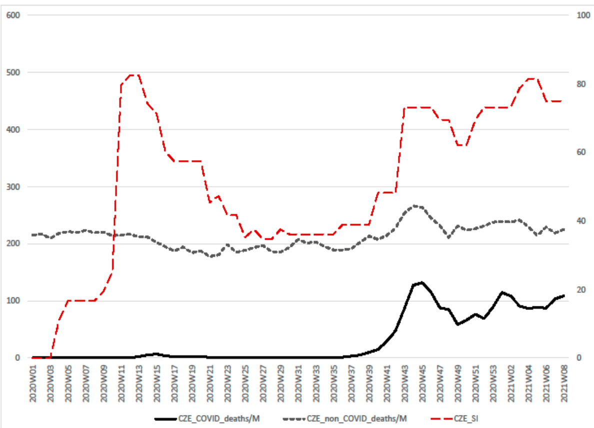

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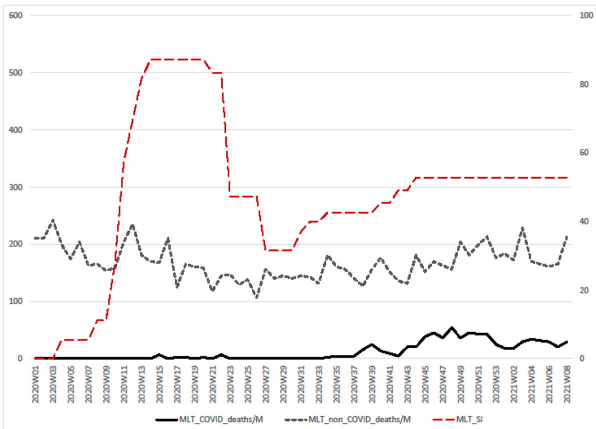

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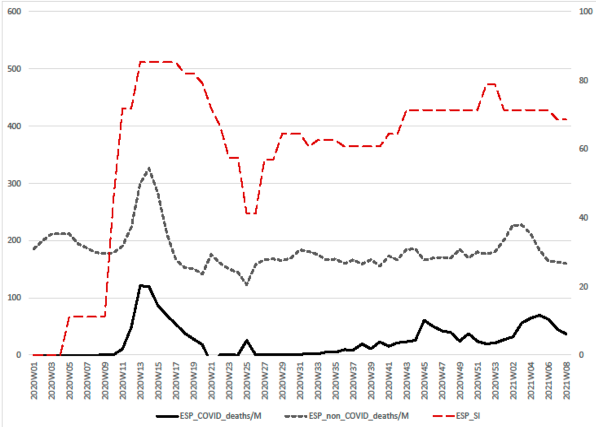

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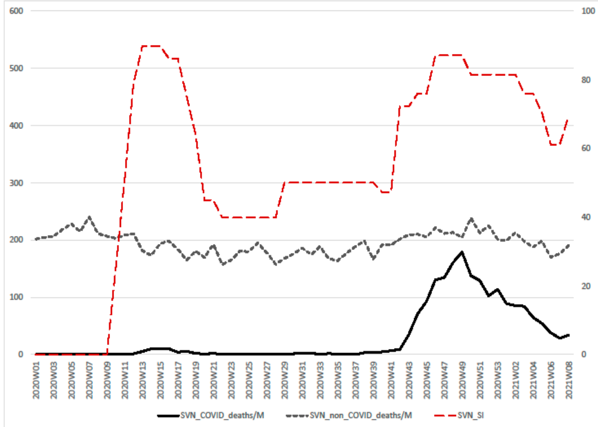

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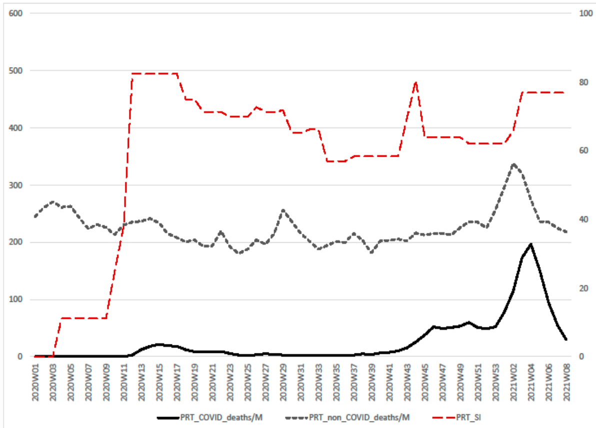

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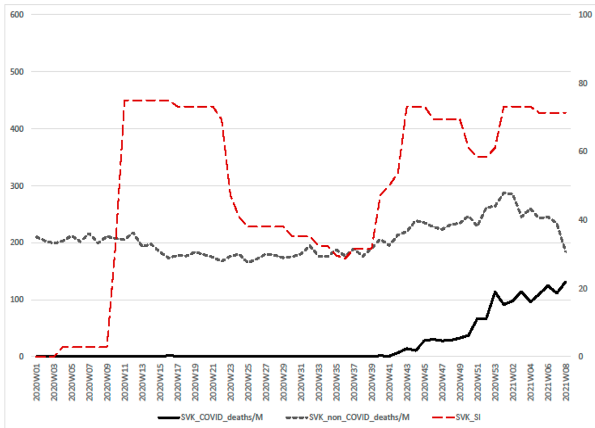

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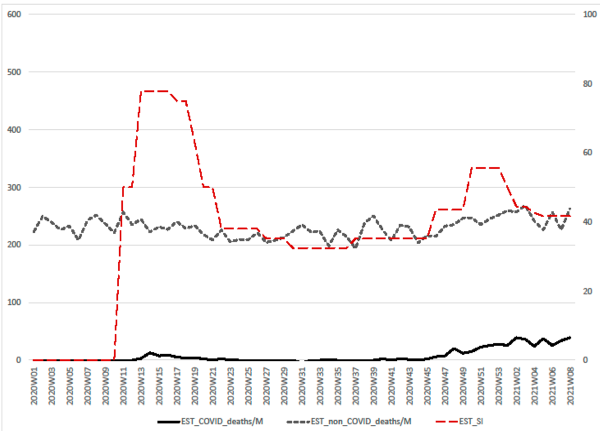

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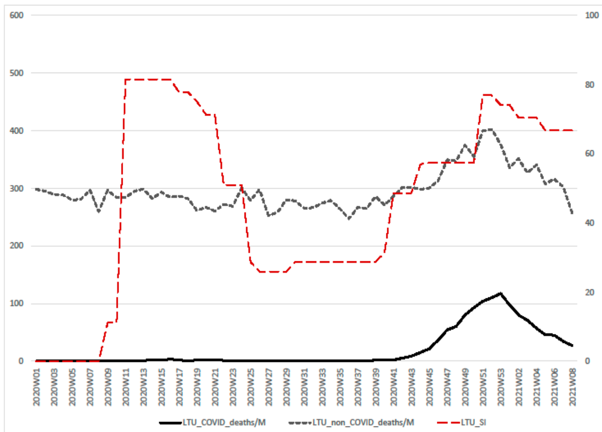

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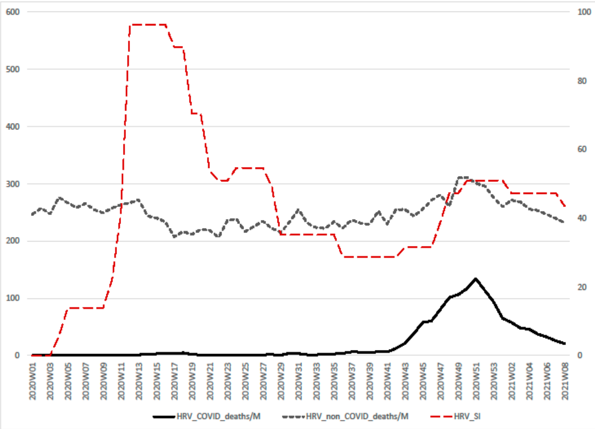

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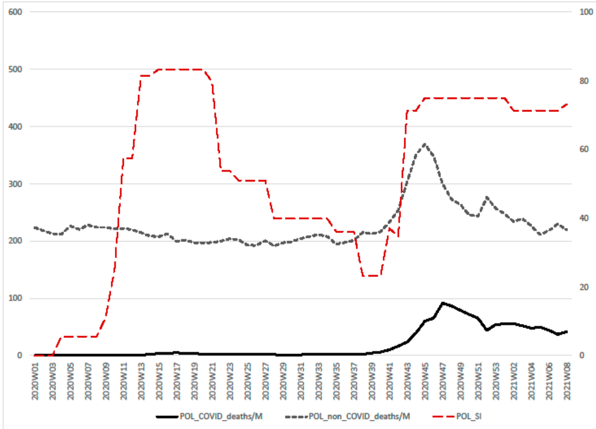

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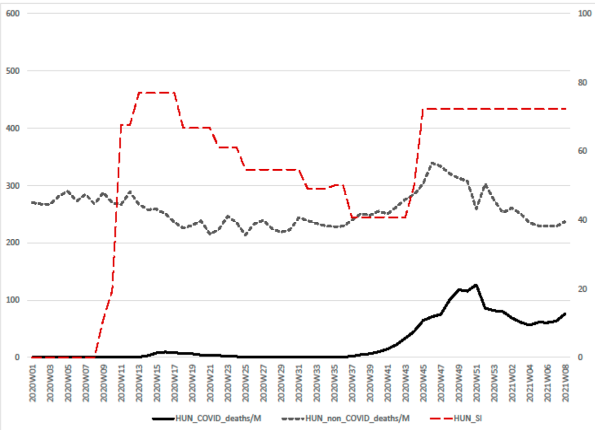

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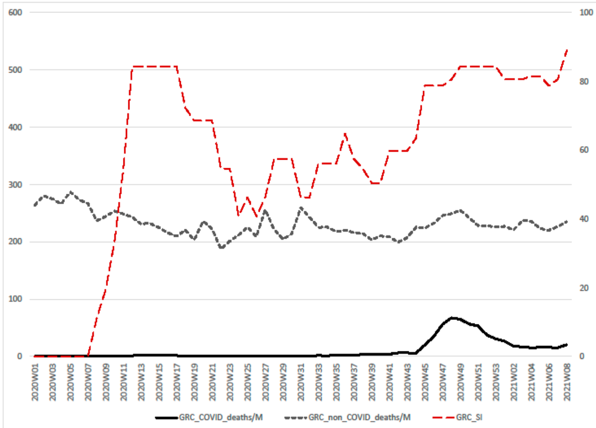

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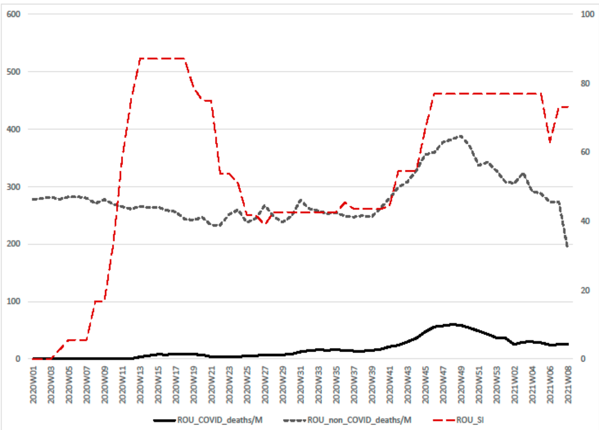

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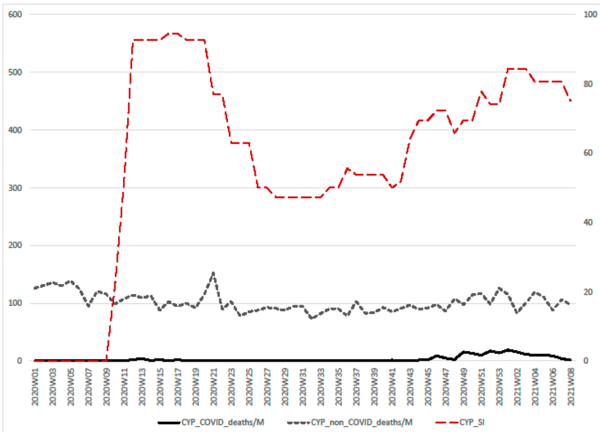

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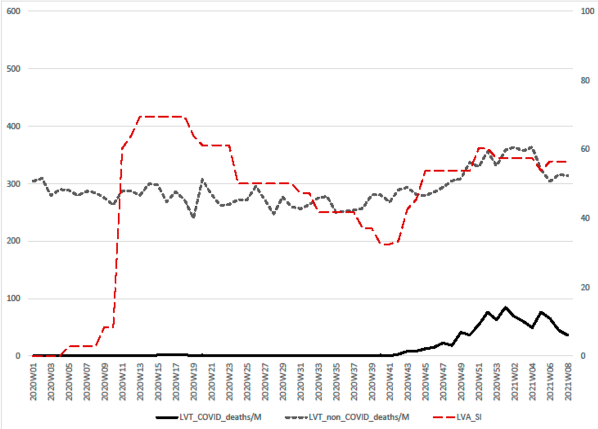

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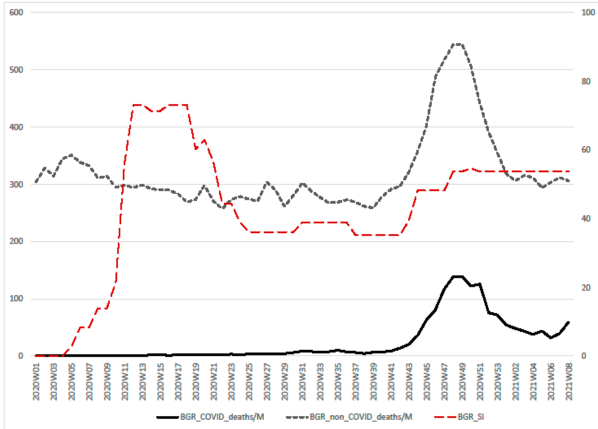

Bulgaria

Figure 1. Stringency index (dashed red lines, auxiliary axis) versus COVID deaths per million (solid black line, the main axis) and non-COVID deaths per million (dotted gray line, the main axis) in countries sorted by the average compulsory health spending per capita during 2016–2019 (data in Table 1)

Source: oxCGRT – Eurostat 2021b; Hale et al. 2021; OECD 2022 database.

In the second subperiod, the trend was still upward in Portugal, Slovenia, and Denmark, but downward in Cyprus, Czechia, Serbia, and Iceland, although the relationship with SI was still positive there (except in Iceland). Concerning the relationships with a constant – the latter was positive in Poland, Norway, and Denmark, but negative in Slovenia and Cyprus. In all those cases, apart from Poland, the relationship with SI was positive, i.e. the growth in mortality led the increase in SI. Only in Poland did the growth in SI lead to a decrease in the non-COVID mortality rate. The most striking difference is that the average week-by-week change of non-COVID mortality in Poland was the highest among all the countries, equalling 394 deaths per 1000 inhabitants, while each increase in SI contributed to the decrease of this rate by 1 person per million inhabitants.

The resulting relationship can be interpreted as follows: if the government imposed no restrictions, the non-COVD mortality would increase week by week by 394 per million citizens. This suggests that either some COVID deaths were incorrectly classified as non-COVID deaths or that the non-COVID mortality increased during the pandemic due to the general panic and closure of healthcare facilities. One can formulate similar conclusions for Serbia, where the growth of SI by 1 point contributed to an increase in non-COVID mortality by 155 per million, and the overall trend of non-COVID deaths was downward sloping. However, in the prevailing cases, the increase in non-COVID mortality seemed to enhance the government to increase the general restrictions. A negative relationship was also observed in Switzerland and Croatia.

The restrictions should not affect non-COVID mortality. Therefore, when the relationship is negative, we can conclude that some of the deaths may have been incorrectly classified as COVID ones, and, consequently, we observed a decrease in non-COVID mortality. Another possible explanation is that the stay-at-home restrictions led to a reduction in other deaths, e.g. from car accidents or other infectious diseases. On the other hand, when the relationship is positive, one can conclude that the restrictions were too severe and led to excess mortality.

Links between health spending, COVID, and non-COVID deaths

In the following subsection, we focus on the possible linkages between the COVID and non-COVID fatalities and the condition of the healthcare system, measured by compulsory government expenditure on health protection (Government/Compulsory Health spending per capita in USD, the annual average 2016–2019). The data come from the OECD (2022) database.

Figure 1 is a set of graphs showing the weekly deaths in countries normalised for population size (deaths per million population): deaths because of COVID–19 and deaths because of other causes and the weekly SI. The countries were sorted by the average healthcare spending per capita.

We can see some links between government spending on health and the trajectory of non-COVID deaths. In countries where the expenditure on health is the highest (e.g. Norway, Denmark, Finland), there are no significant changes in the trajectory of non-COVID deaths. However, one or two waves of COVID deaths are clearly visible. It is also related to the age structure of the population and the relatively high life expectancy. The age structure was crucial for mortality, especially in the first phase of the pandemic (Sornette et al. 2020).

Belgium draws our attention with a significant increase in non-COVID deaths between weeks 32 and 34 (August) of 2020 – a consequence of the heatwave (Sciensano 2021). A large number of non-COVID and COVID deaths in the United Kingdom at the beginning of the pandemic can be explained by two phenomena. The number of deaths directly related to COVID–19 was underestimated (Kontopantelis et al. 2021), and the National Health Service was unable to cover the patients who needed it. During the first wave of the Covid–19 pandemic, only a third of people in the UK were able to obtain the hospital care they needed (Davillas and Jones 2021).

The first two countries in Europe caught by the pandemic (Italy and Spain) saw a significant increase in non-COVID deaths during the first weeks of the pandemic, accompanied by a wave of COVID deaths. It may stem from the fact that neither the data reporting system was perfect, nor were the healthcare systems able to properly care for all those in need. In Czechia and Slovenia, there was an increase in COVID deaths during the second wave of the pandemic (autumn, 2020). In Czechia, it co-occurred with the increase in non-COVID deaths.

There was a particularly high rise in non-COVID deaths (as well as COVID-related ones) during the second wave of the pandemic in countries where the expenditure on healthcare is low. The situation was particularly alarming in the autumn of 2020 in Bulgaria, Lithuania, Romania, Latvia, and Poland, where the average number of non-COVID deaths per million inhabitants was the highest. For most countries with low health expenditure (except for Estonia, Cyprus, and Greece), the number of non-COVID deaths grew by half, doubled, or even more during the second wave of the pandemic (autumn 2020) (see Table 1).

Discussion and conclusions

The paper presented the results of the analysis of the relationships between COVID and non-COVID mortality and the stringency index during the first year of the COVID–19 pandemic to better understand the consequences of the efforts taken by governments during that tough time. We demonstrated that, most often, if there was a relationship between the SI and COVID mortality (research question 1) or non-COVID mortality (research question 2), it was usually positive and mortality driven. That indicates that the governments responded to the COVID pandemic and adjusted the SI accordingly; however, the mortality hardly ever responded to the restrictions. No relationships, or negative ones, were found in countries where the spending on healthcare was high, i.e. Northern and Western European countries. Especially troubling are the observed weekly non-COVID death changes during the second sub-period of the first year of the pandemic. They are the most alarming for the CEE countries, where government healthcare expenditures per capita are low. The only exception is Czechia (see Table 1), where spending exceeded that of Spain and Portugal.

Almost all CEE economies came through the first subperiod of the pandemic reasonably well (in Romania and Slovakia, the changes in SI preceded the changes in non-COVID mortality, while in Latvia and Slovakia, the lowest maximal weekly changes in COVID deaths occurred in the first subperiod). However, these countries were badly affected during the second autumn subperiod. The maximum weekly change in COVID deaths (per million) in that period ranged from 39.20 (Estonia) to 169.80 (Slovenia), and in 7 of the 12 CEE countries, the maximum exceeded 100 per million citizens. What is equally worrying is that countries in this group noted very high increases in non-COVID deaths during the second subperiod, with maximum weekly increases ranging from 238.58 (Slovenia) to 544.73 (Bulgaria). Thus, even if the countries succeeded in reducing COVID-related mortality, they failed to mitigate the non-COVID deaths. It might indicate that all the resources in the under-financed health sector were switched to fighting COVID, leaving very little for other illnesses.

It is, therefore, hard to deny that there is a link between the evolution of the pandemic and healthcare expenditures. We are aware that we cannot speak of causality here but co-occurrence. Moreover, the lack of a long-run relationship may be a consequence of the stationarity of some series or their non-standard properties, such as fractional integration. Thus, COVID mortality and SI may have been interconnected in more complex ways, which we have not discovered in our study.

The main conclusion from our research is that the countries where government spending on health (*per capita*) is relatively low should make every effort to minimise disparities in allocating resources for treating various diseases.

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Umieralność i wydatki na ochronę zdrowia w pierwszym roku pandemii COVID–19. Porównanie krajów Europy Środkowej, Wschodniej i Zachodniej

W artykule przedstawiono zależności między liczbą zgonów zakwalifikowanych jako zgony z powodu COVID–19 oraz liczbą zgonów z innych przyczyn w pierwszym roku pandemii, w zestawieniu z surowością wprowadzonych ograniczeń i obowiązkowymi wydatkami na opiekę zdrowotną w większości krajów europejskich. Analizujemy dane tygodniowe i stosujemy modele kointegracyjne. Z uwagi na intensywność zachorowań w badanych krajach, dzielimy okres na dwie podpróby: marzec – sierpień 2020 oraz wrzesień 2020 – luty 2021. Stwierdzamy, że najczęściej, jeśli występowała zależność między SI a umieralnością z powodu COVID lub nie-COVID, to była ona dodatnia, a zmienną wiodącą była umieralność. Sugeruje to, że chociaż rządy dostosowały ograniczenia do rosnącej liczby zgonów, nie były w stanie opanować pandemii. Brak zależności lub zależności ujemne najczęściej występowały w tych krajach, w których wydatki na opiekę zdrowotną były najwyższe (czyli w krajach Europy Północnej i Zachodniej). Największe tygodniowe zmiany liczby zgonów niezwiązanych z COVID w drugim podokresie obserwowano w krajach Europy Środkowej i Wschodniej, gdzie wydatki rządowe na opiekę zdrowotną per capita są najniższe.

Słowa kluczowe: umieralność z powodu COVID, Stringency Index, umieralność z przyczyn innych niż COVID, test Johansena, kointegracja, wydatki na opiekę zdrowotną