RECENT EXCESS MORTALITY IN SELECTED STATES OF THE EUROPEAN UNION

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Abstract

The aim of the paper is to assess the excess mortality in the states of the EU with the highest Covid-19 mortality and to compare whether the development of excess mortality corresponds to the Covid-19 mortality development to see the influence of the pandemic on mortality. The data about excess mortality were taken from Eurostat and about mortality for Covid-19 from WHO. The highest mortality was in Bulgaria (543 deaths per 100 000 inhabitants from the beginning of Covid-19 pandemic till mid-August 2022), Hungary (485), Croatia (411), Czechia (381) and Slovakia (372). From the graph it can be seen that there is the same development trend of mortality for Covid-19 and excess mortality. Both time series are seasonal and strongly correlate that was measured by Pearson correlation coefficient. We used Johansen cointegration test to assess whether there is a long-term relationship between two time series. There was found a cointegration of time series of excess mortality development and Covid-19 development for 4 countries with exception of Croatia. However, the correlation coefficient pointed out on strong positive linear relationship. Hence, the excess mortality is influenced by the Covid-19 pandemic.

Key words: cointegration, Covid-19, European Union, excess mortality, mortality

JEL Code: Q18, J43, J62

Introduction

Since the breakthrough of the Covid-19 pandemic, there has been high excess mortality noted in many countries as it's a consequence. "Excess mortality is an essential epidemiological indicator to monitor the capability of healthcare systems." (Buja et al., 2022). The excess mortality is calculated from comparison of the total number of deaths from all causes with the expected number of deaths during a certain period in the past (baseline). "Excess Mortality" is the rate of additional deaths in a month compared to the average number of deaths in the same month over a baseline period." (Eurostat, 2021) The waves of Covid-19 disease dramatically increased mortality rates and excess mortality across countries. "Mortality varies by time and location, and its measurement is affected by well-known biases that have been exacerbated during the COVID-19 pandemic." (Wang et al., 2022). It is important to measure the number of deaths for Covid-19 and to examine what factors influence it as well as to assess the excess mortality and the contribution of Covid-19 to it. "An accurate measurement of the number of deaths due to the Covid-19 pandemic is crucial for each country and region to understand the magnitude of the pandemic's impact on public health." (Wang et al., 2022).

Hence, many studies have emerged since the pandemic breakthrough. For example, excess mortality in 191 countries was examined in a large study by Wang et al. (2022). They estimated that 18.2 million (95% uncertainty interval 17.1–19.6) people died worldwide because of the Covid-19 pandemic (as measured by excess mortality) over that period.

Leon-Gomez et al. (2021) found out that the excess mortality estimated at the beginning of March 2020 in Spain was much greater than what has been observed in previous years, and clustered in a very short time. Besides, the cumulated excess mortality increased with age. Silva, Jardim and dos Santos (2020) examined excess deaths in Brazil from March to May 2020 and found out that excess mortality was higher among men. Buja et al. (2022) examined excess mortality during the first phase of the Covid-19 outbreak in Italy. They found out that health and healthcare variables (in particular, the density of physicians) are strongly associated with excess mortality.

Cronin and Evans (2021) used USA data on weekly death counts by cause, as well as life tables, to quantify excess mortality and life years lost from both Covid-19 and non-Covid-19 causes by ethnicity, age, and sex. Also Wan et al. (2022) examined the factors that influence the mortality of Covid-19. They put data, such as disease history and lifestyle factors, from the Covid-19 patients, into three machine learning models. Age, lifestyle, illness, income, and family disease history were identified as important predictors of Covid-19 mortality. (Wan et al., 2022).

Corrao, Rea and Blangiardo (2021) compared the trends of mortality rate, case-fatality and all-cause excess mortality in Austria, Belgium, Canada, France, Germany, Italy, Netherlands, Spain, Sweden, UK, USA. They found that Belgium ranks first in mortality from Covid-19, but not first in all-cause excess mortality. On the other hand, UK, Italy and Spain reported lower Covid-19 mortality, but higher all-cause excess mortality. "Between-country heterogeneity of Covid-19 mortality metrics could be largely explained by differences of criteria for attributing a death to Covid-19; in age/comorbidity structures; in policies for identifying asymptomatic people affected from SARS-CoV-2 infection." (Corrao, Rea and Blangiardo, 2021).

1 Data and Methods

The aim of the paper is to assess the excess mortality in 5 states of the EU with the highest mortality on Covid-19 and to compare whether the development of excess mortality corresponds to the Covid-19 mortality development to see the influence of the pandemic on mortality.

The data about excess mortality were taken from Eurostat (Eurostat, 2022). The monthly excess mortality indicator is expressed as the percentage rate of additional deaths in a month, compared to a baseline period (average monthly deaths in the period 2016–2019). “The higher the value, the more additional deaths have occurred compared to the baseline. A negative value means that fewer deaths occurred in a particular month compared with the baseline period.” (Eurostat, 2021). Data about daily mortality for Covid-19 were taken from World Health Organization (WHO, 2022). The data was recalculated on monthly data to correspond to the date of excess mortality that are with monthly frequency (only data from the last day of the particular month were taken into account).

When the number of inhabitants is taken into account, the highest mortality was in Bulgaria (543 deaths per 100 000 inhabitants from the beginning of Covid-19 pandemic till mid-August 2022), Hungary (485), Croatia (411), Czechia (381) and Slovakia (372). Therefore, we examined those five countries.

At the beginning, we calculated Pearson correlation coefficients between the time series of excess mortality and Covid-19 mortality and measured linear dependence between those two.

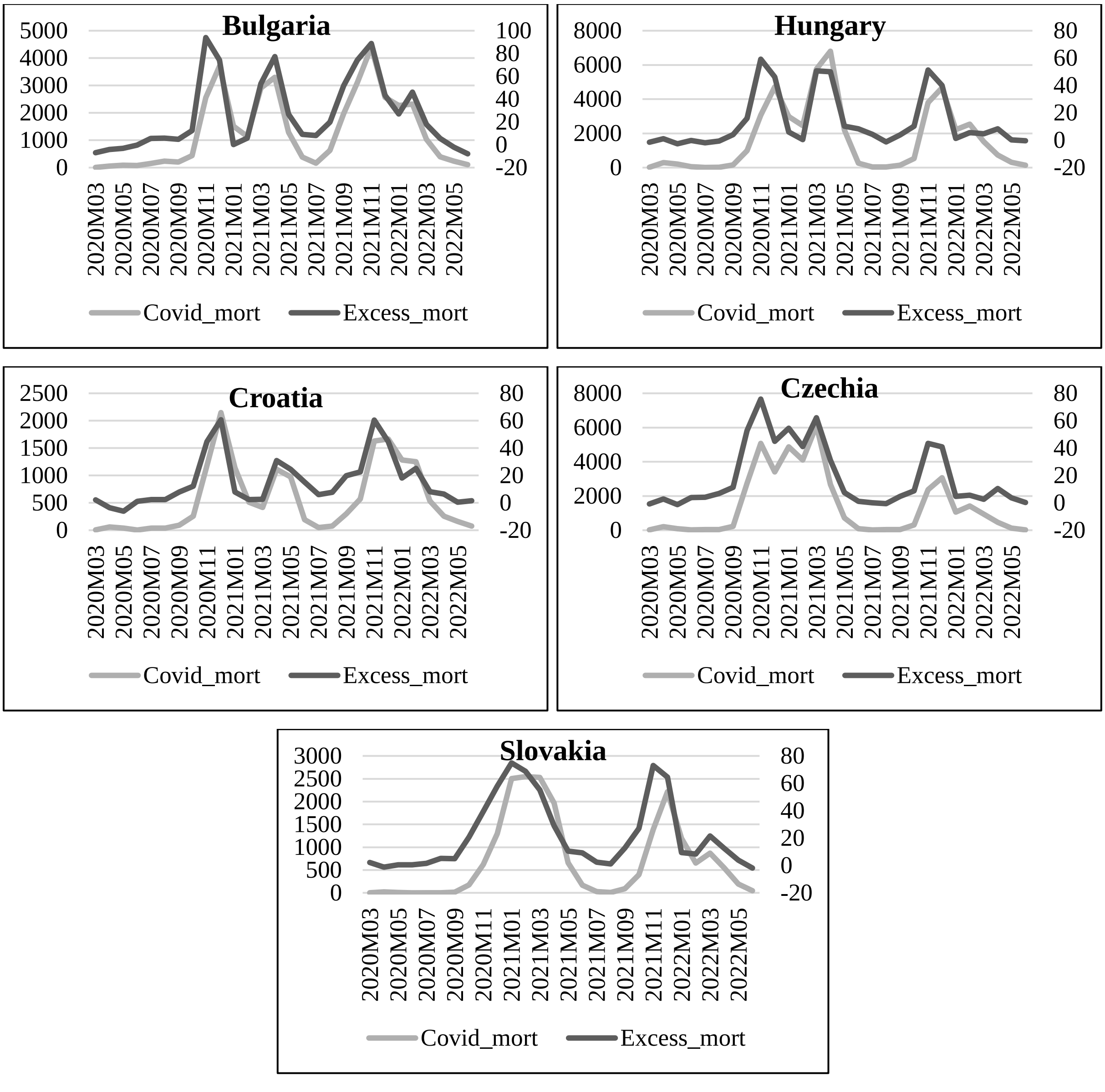
A Johansen cointegration test was used next to assess whether there is a cointegration between time series of excess mortality and number of deaths for Covid-19. The null hypothesis states that there is no cointegration (i.e. there is no cointegrating equation – linear combination of the time series) against the alternative hypothesis of cointegration.

The presumption of application of Johansen test is that the both time series are non-stationary which was tested by Augmented Dickey-Fuller test. Null hypothesis of this test states that the series possesses a unit root and hence is not stationary while alternative hypothesis assumes stationarity. Consequently, it must be tested whether the regression of those time series is not spurious. It was done by Granger test for spurious regression. Finally, the cointegration tests were done for each pair of time series.

2 Results

By mere display of the graphs of development of the mortality for Covid-19 and excess mortality (see Fig. 1), it can be seen that there is a same development trend in particular month or month later at least. Covid-19 mortality exceeds excess mortality almost through the whole period in all countries with only several exceptions. Mortality of Covid-19 seems to be an important part of excess mortality. Both types of time series have clearly visible seasonality as there are waves of Covid-19 and the virus is weaker in summer. When the value of excess mortality is negative (e.g. in Hungary at the beginning of the period) it means that fewer deaths occurred in a particular month compared with the baseline period 2016–2019.

Fig. 1: Development of Covid-19 mortality and excess mortality



Source: own elaboration based on data from Eurostat (2022) and WHO (2022)

The question is whether there is real relationship between those two time series. There can be mutual linear dependence (correlation) or long-term relation (cointegration).

The Pearson correlation coefficients between Covid-19 mortality and excess mortality are high and all are statistically significant at 0,05 significance level. The highest positive linear dependence was in Czechia (0,946), then in Bulgaria (0,923). For Croatia (0,878) and Slovakia (0,870) had the correlation coefficient almost the same value. The lowest correlation was calculated in Hungary (0,835).

The outcomes of cointegration testing are displayed at Fig. 2. The summary results of the Johansen test indicate whether there could be a cointegration, i.e. that one series can be expressed as linear combination of the other i.e. there is a long run relationship between the development of the mortality for Covid-19 and excess mortality.

The methodology searches for cointegration vector (vectors) that emerges from linear (or quadratic) function with or without the intercept or trend. The Johansen test then examine how many cointegration vectors are there (none, at most 1, at most 2 – as we have 2 time series for examination). The algorithm advised the maximum number of cointegration vectors based on the minimum value of the information criteria – Akaike and Schwarz information criteria.

Due to low number of observations (we have time series only from 03/2020 to 06/2022) we have to talk only about the possibility of existence of the cointegrating vectors. For more precious results we would need to add more observations (e.g. we shall have daily data instead of monthly data).

For the case of Bulgaria, there exist one linear combinations of time series as there is at most 1 cointegration vector (see Akaike and Schwartz information criteria). Null hypothesis of no cointegration was rejected at 0.05 level. Same situation was found for the case of Hungary, Czechia and Slovakia. There is also at most 1 cointegration vector. There is one possible way how to express one time series as linear combination of the other. Therefore, there could be a long-term relationship between the development of the mortality for Covid-19 and excess mortality. We should examine more observations to confirm this finding.

On the other hand, in Croatia was found any cointegration vector, so there is no cointegration between two examined time series. In spite of this, the correlation between those two time series is high also in this country.

We can therefore see a strong influence of the Covid-19 pandemic on the mortality in five examined countries in the EU with the highest Covid-19 mortality.

Fig. 2: Cointegration of Covid-19 mortality and excess mortality (03/2020-06/2022)

Bulgaria

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	2	0	2
Max-Eig	1	0	0	0	0

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	-301.4073	-301.4073	-301.4045	-301.4045	-300.4498
1	-294.2912	-294.2910	-294.2907	-294.2367	-293.3079
2	-293.4912	-291.2579	-291.2579	-291.2038	-291.2038
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	24.75259	24.75259	24.91236	24.91236	24.99599
1	24.50329*	24.58328	24.66325	24.73894	24.74463
2	24.75930	24.74063	24.74063	24.89630	24.89630
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	25.14263	25.14263	25.39991	25.39991	25.58105
1	25.08836*	25.21710	25.34582	25.47026	25.52471
2	25.53938	25.61822	25.61822	25.87140	25.87140

Hungary

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	2	1	2
Max-Eig	1	1	2	1	2

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	-305.5361	-305.5361	-305.5313	-305.5313	-305.1552
1	-294.9340	-294.9283	-294.9243	-294.7153	-294.3455
2	-293.6335	-290.8228	-290.8228	-290.5966	-290.5966
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	25.08288	25.08288	25.24251	25.24251	25.37241
1	24.55472*	24.63426	24.71395	24.77722	24.82764
2	24.77068	24.70583	24.70583	24.84773	24.84773
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	25.47292	25.47292	25.73006	25.73006	25.95747
1	25.13978*	25.26808	25.39652	25.50855	25.60772
2	25.55076	25.58342	25.58342	25.82283	25.82283

Croatia

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	2	0	2
Max-Eig	0	0	0	0	0

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	-269.8567	-269.8567	-269.8224	-269.8224	-268.8636
1	-264.5478	-263.0381	-263.0355	-261.7509	-261.0610
2	-263.6631	-259.2534	-259.2534	-257.9529	-257.9529
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	22.22853	22.22853	22.38579	22.38579	22.46909
1	22.12382	22.08305*	22.16284	22.14007	22.16488
2	22.37305	22.18027	22.18027	22.23623	22.23623
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	22.61857*	22.61857*	22.87334	22.87334	23.05415
1	22.70888	22.71686	22.84541	22.87140	22.94496
2	23.15313	23.05786	23.05786	23.21133	23.21133

Czechia

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	2	1	2
Max-Eig	1	1	2	1	2

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	-295.9953	-295.9953	-295.9885	-295.9885	-295.4639
1	-284.8144	-284.5740	-284.5706	-282.8202	-282.2956
2	-283.6156	-280.8939	-280.8939	-278.0884	-278.0884
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	24.31962	24.31962	24.47908	24.47908	24.59711
1	23.74515*	23.80592	23.88564	23.82562	23.86365
2	23.96925	23.91152	23.91152	23.84707	23.84707
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	24.70966	24.70966	24.96663	24.96663	25.18217
1	24.33021*	24.43974	24.56821	24.55694	24.64373
2	24.74933	24.78911	24.78911	24.82217	24.82217

Slovakia

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	2	1	2
Max-Eig	1	1	2	1	2

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	-271.6031	-271.6031	-271.5940	-271.5940	-271.0276
1	-260.7008	-260.1246	-260.1246	-260.1245	-259.5581
2	-259.6739	-256.0237	-256.0237	-255.9749	-255.9749
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	22.36825	22.36825	22.52752	22.52752	22.64221
1	21.81607*	21.84997	21.92996	22.00996	22.04465
2	22.05391	21.92189	21.92189	22.07799	22.07799
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	22.75829	22.75829	23.01507	23.01507	23.22727
1	22.40113*	22.48378	22.61254	22.74128	22.82473
2	22.83399	22.79948	22.79948	23.05310	23.05310

Source: own elaboration

Conclusion

The aim of the paper was to assess the excess mortality in the states of the EU with the highest Covid-19 mortality (Bulgaria, Hungary, Croatia, Czechia and Slovakia) and to compare whether the development of excess mortality corresponds to the Covid-19 mortality development to see the influence of the pandemic on mortality.

We used time series from 03/2020 to 06/2022 for examination. First, the development was displayed in graphs. Then, the Pearson correlation coefficient was calculated and finally, the Johansen cointegration test was performed.

There was a cointegration found for Bulgaria, Hungary, Czechia and Slovakia so we assume a long-term relationship in the model despite the fact that the series are drifting apart or trending either upward or downward differently. The development of mortality for Covid-19 and excess mortality form an equilibrium in the long-run. However, the cointegration was not found for the case of Croatia. On the other hand, the values of correlation coefficients were high for all countries suggesting that there is strong linear relationship between those two variables. Besides, the development of mortality for Covid-19 and excess mortality in time is very similar.

Therefore, we can conclude that in the examined countries there is a long-term relationship between mortality for Covid-19 and excess mortality, hence, the pandemic had strong influence on the mortality.

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