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ECONOMIC DEMOGRAPHY II

Impact of Covid-19 pandemic on mortality in selected European countries in 2020 and 2021

Author
HANA VRBATOVÁ

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1 Introduction

For Europe, Covid-19 pandemic was the most significant crisis of a few past decades. It impacted economy, social relationships, politics and many other areas. This paper explores the impact of Covid-19 pandemic on mortality in European countries in 2020 and 2021. Understanding the outcome of this pandemic is crucial in preparation for the next great crisis.

This paper does not focuses on the development of daily new cases of Covid-19, instead it focuses on excess mortality. It takes advantage of new indicators describing mortality conditions in European countries, that were newly established in reaction to the new situation. For governments, experts and public, it was essential to have relevant data to make appropriate decisions. Therefore, some data about mortality were published more frequently.

Comparing data about deaths caused by Covid-19 virus between countries and even across time in one country could be tricky as the definition is not harmonised and not clear. For that reason, excess mortality could be better indicator to capture differences in the impact of the pandemic on mortality in European countries. One of the most used mortality indicator is life expectancy - the main outcome of life tables that are faithful depiction of mortality conditions in the country in that year.

The results are presented with broader background about protective measures declared to fight against the pandemic. For 2020, it were mainly restrictions of the movement across borders and within the country or administrative district with the exception of work related matters, mandatory to wear a face mask, cancellation of public events up to certain number of people, closing unessential businesses, etc. In 2021, the main strategy focused on vaccination campaign. There were two major problems, logistics - how to vaccinate as many people as possible in the shortest possible time period - and willingness of people to get the vaccine.

The analysis explores how the strict protective measures declared by the government helped to lessen the effect of the pandemic on mortality. On the other hand, it is important to highlight even the negative effects of these restrictive measures - especially on economy and relationships between people. The question if these restrictions were really worth it could be asked. With the understanding of the virus from 2020 and 2021, it is evident, that for lessening the impact, it was necessary to protect those who were the most vulnerable. For this virus it were elderly people who usually suffer from additional health problems.

2 Data and methods

In response to Covid-19 pandemic, many organisations, that are responsible for dissemination of data about mortality in not only European countries (eg., Human Mortality Database, Eurostat, WHO, ...), established new indicators for measuring intensity of mortality. Most of these indicators are short-term oriented to monitor development of the pandemic and provide vital data for experts in different scientific fields to study, for the government to make protective measures and public to educate themselves. This paper takes advantage of this fact. Data used in this paper are from Eurostat database that is available to public.

Analysing impact of Covid-19 pandemic on mortality using indicators based on cause of death (the cause would be coronavirus Covid-19), would not be wise. There is no harmonisation of the definition death by coronavirus Covid-19 across countries. Therefore, for analysing the differences and similarities of the impact of Covid-19 pandemic on mortality between European countries, the indicator *Excess mortality by month* is used. This measure shows the rate of additional deaths comparing to the baseline period, in this case average monthly deaths in period 2016-2019 and unit of this measure is percentage rate (increase or decrease). Higher values indicates more additional deaths compared to baseline, negative values mean fewer deaths compared to baseline. Assuming that excess mortality is caused by deaths that could have been avoided if the Covid-19 pandemic did not happen or the government took more fitting protective measures. As of June 14, available data are for period from January 2020 to March 2022, however, this paper focuses only on years 2020 and 2021 (i.e., 24 months). Data are available for 31 European countries:

Belgium, Bulgaria, Czechia, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, Iceland, Lichtenstein, Norway and Switzerland.

Comparing time series of all 31 countries at the same time would be challenging, as evident in figure 3 (b). This paper groups countries into 5 categories regarding their similarities of excess mortality based on clustering, utilising classical partitioning technique around medoids - one object in the cluster with minimum dissimilarities with all the others - with PAM algorithm. K-medoids method is more robust to noise and outliers and do not require Euclidean distance in contrast with k-means method. For time series clustering it is preferable to apply Dynamic Time Warping algorithm for measuring similarity. Initial selection of medoids is random. Therefore, for needs of this paper, clustering was repeated 100 times and the best result was selected based on the values of F-measure as the evaluation measure. Medoid of each cluster was selected as a representative of the group, with the exception of cluster 1 - representative of this cluster is Czechia, instead of Poland.

Furthermore, this paper analysis the effect of Covid-19 pandemic on life expectancy in 2020 in contrast to the average of 2016 to 2019. It is explored if the pandemic caused a decline of life expectancy, how big the effect was and which age groups were most impacted using age-decomposition method by Andreev (1982) for both sexes in 5 countries (one from each cluster): Czechia, Italy, Portugal, Greece and Germany. Used data are from Eurostat database, by the beginning of June, life tables for those 5 countries were available only for 2020, not for 2021 yet. Therefore, analysis is done only for 2020. For age-decomposition and calculation of the differences for life expectancy at birth were used indicators *The number of people who survive to age x from the radix* and *The remaining life expectancy for people at age x*. The average of years 2016 to 2019 was chosen as a baseline to follow the logic used in the indicator *Excess mortality by month* by Eurostat. Time comparison of the year 2020 (when pandemic happen) and the years before (simple average to eliminate random anomalies) enables to fully understand the impact of the pandemic in context of the country's health, social, demographic, economic, cultural and environmental circumstances.

3 Results

This paper explores similarities of the effect of Covid-19 on mortality in European countries in 2020 and 2021. Based on these resemblances, 31 countries were split into 5 groups:

- Cluster 1:
  - Bulgaria, Croatia, Czechia, Hungary, Poland, Romania, Slovakia, Slovenia
  - Representative: **Czechia**
- Cluster 2:
  - France, Italy, Malta, Netherlands, Spain
  - Representative: **Italy**
- Cluster 3:
  - Belgium, Cyprus, Iceland, Ireland, Liechtenstein, Portugal, Sweden
  - Representative: **Portugal**
- Cluster 4:
  - Austria, Denmark, Estonia, Finland, Greece, Luxembourg, Norway
  - Representative: **Greece**
- Cluster 5:
  - Germany, Latvia, Lithuania, Switzerland
  - Representative: **Germany**

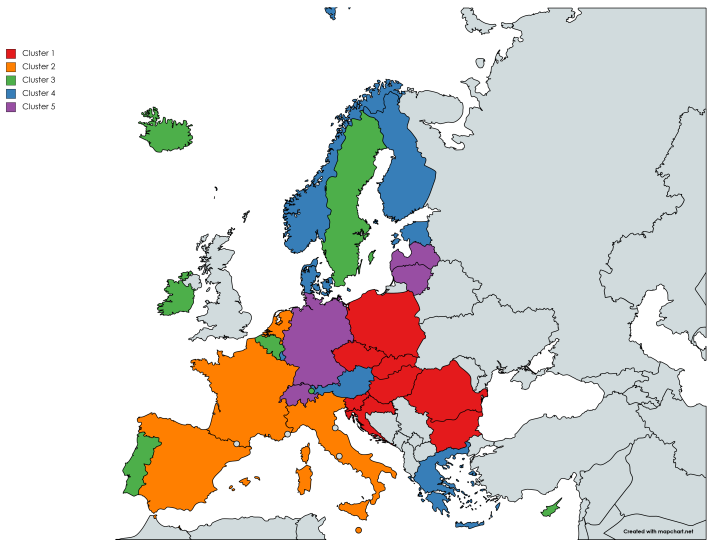

Figure 1: Map of European countries split into 5 groups after clustering

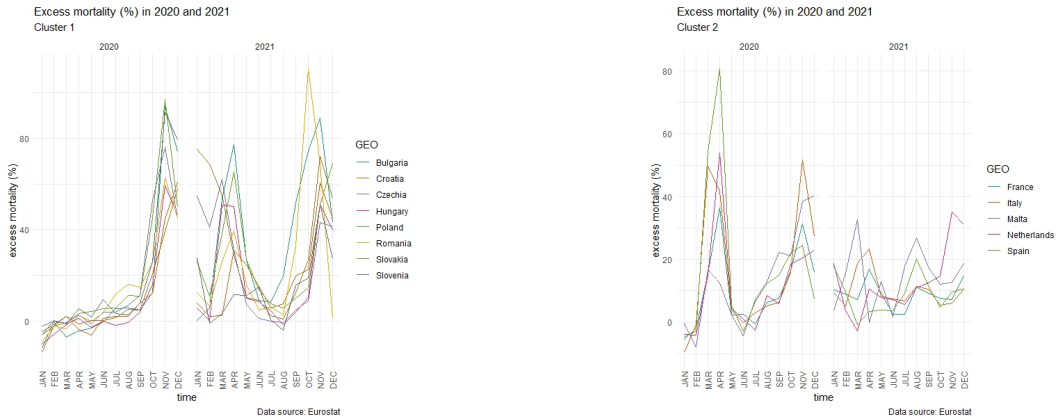

Figure 2: Monthly excess mortality (%) for cluster 1 and cluster 2 in 2020 and 2021

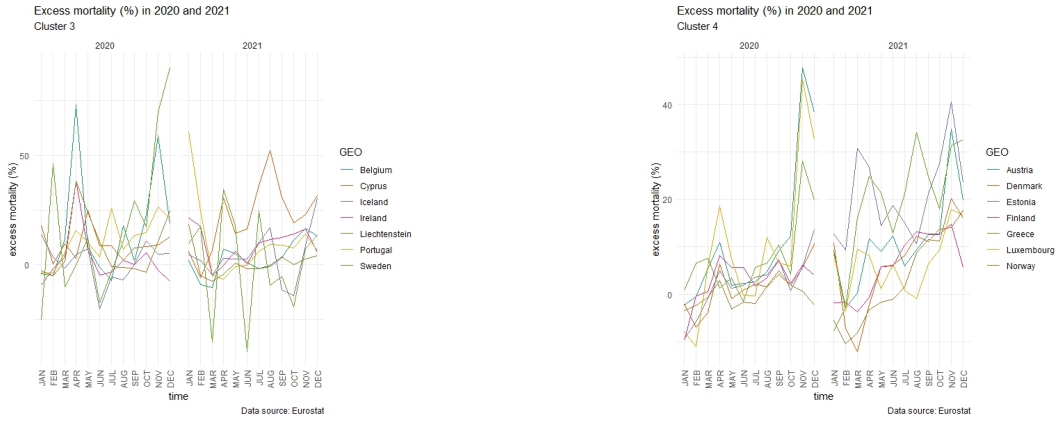

Figure 3: Monthly excess mortality (%) for cluster 3 and cluster 4 in 2020 and 2021

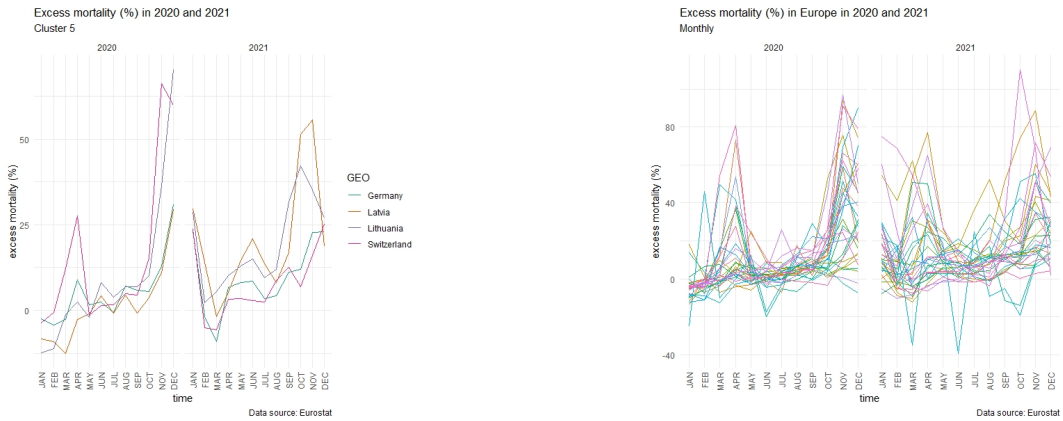

Figure 4: Monthly excess mortality (%) for cluster 5 and all 31 countries in 2020 and 2021

In figure 1, it is evident that geographic location had come effect on the development of Covid-19 pandemic. Cluster 1 could be characterise as countries of former Eastern Bloc in Central and Southeast Europe. In cluster 2, as demonstrated, are some countries of Southwestern and Western Europe. Cluster 5 combines most countries of Central Europe without Eastern Bloc history and most countries of Baltic states. Cluster 3 and cluster 4 do not have any significant geographic similarities. Deaths caused by Covid-19 do not reflect the development of the pandemic but the impact on population and mortality. It is expected that excess mortality is slightly delayed in comparison to the increase of new cases.

At first, excess mortality in countries from cluster 1 was low till August 2020. In autumn 2020, the first wave arrived and excess mortality increased over 80 % in some countries. This wave carried over to 2021. In spring 2021, the second wave struck with slightly less force, yet still heavily. During summer months 2021, the situation got almost to baseline again. However, in autumn 2021, the third wave showed up in intensity very much alike the one year before.

On the other hand, in countries in cluster 2, the first wave occurred already in spring 2020 with high excess mortality. The second wave arrived in the same time that the first wave in cluster 1 - autumn 2020 - but was slightly less strong for countries in cluster 2. In 2021, there were smaller waves in different time periods of the year in all countries in this cluster. Nevertheless, none were that intensive as the first wave or as in cluster 1 at that time .

Excess mortality in cluster 3 was never as high as in clusters 1 and 2 for the whole reporting time period. Smaller waves appeared in both years in all countries. In some months, countries had even significantly negative excess mortality.

For countries in cluster 4, excess mortality never exceeded 50 %. First smaller wave arrived in the beginning of 2020, second stronger wave struck at the end of 2020. However, it cannot be compared to the intensity of the wave for cluster 1 at the same time. In 2021, there were usually 2 to 3 medium to high level waves for every country. Nevertheless, not as severe as in cluster 1 in 2021.

In cluster 5, excess mortality was near the baseline for most of the time with the exception of the ends of 2020 and 2021. However, the waves were unquestionably weaker than in cluster 1 at that time.

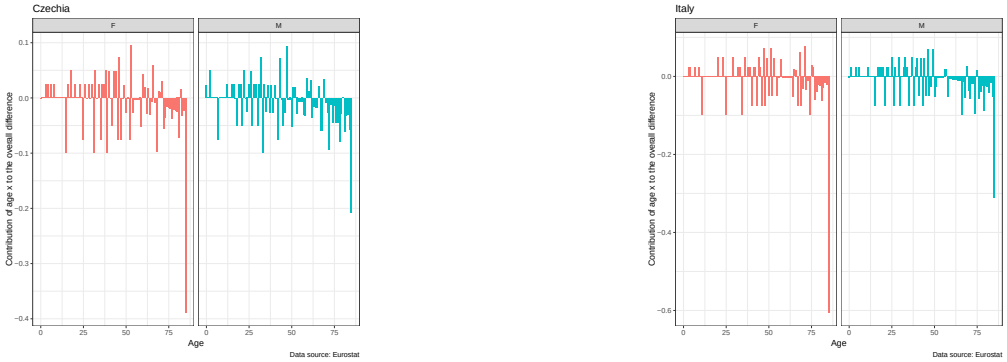

Figure 5: Decomposition of the difference between average life expectancy from 2016 to 2019 and life expectancy in 2021, Czechia and Italy

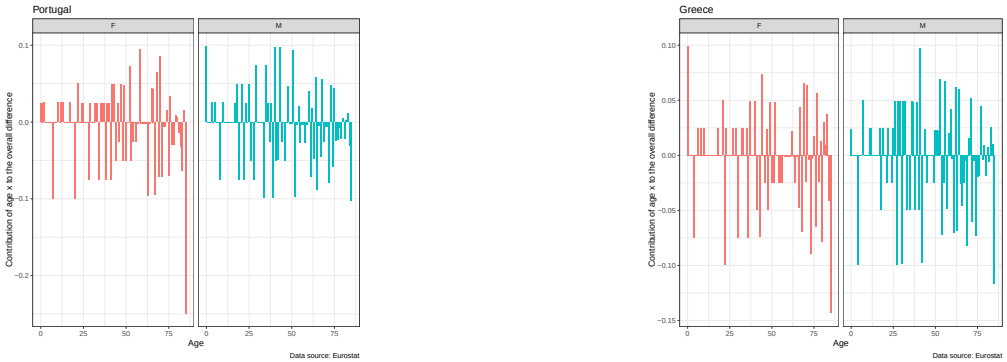

Figure 6: Decomposition of the difference between average life expectancy from 2016 to 2019 and life expectancy in 2021, Portugal and Greece

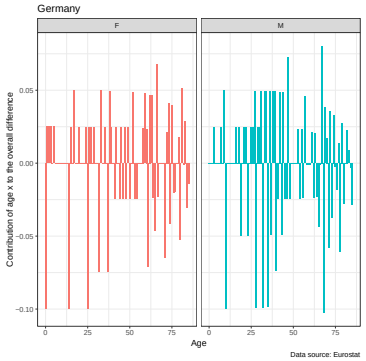

Figure 7: Decomposition of the difference between average life expectancy from 2016 to 2019 and life expectancy in 2021, Germany

In Czechia - country in cluster 1 - life expectancy decreased in 2020 comparing to average life expectancy from 2016 to 2019 for both sexes. The decline was more significant for males. After Italy, the difference between the average and 2020, was the greatest. In figure 5, it is evident, that Czechia was not able to protect the most vulnerable - people over 85 years old. Age group 85+ had the biggest contribution for the drop of life expectancy for both sexes.

In Italy - country in cluster 2 - similarly as in Czechia, life expectancy declined in 2020 in contrast to life expectancy from 2016 to 2019 for both females and males, whereas for males the fall was slightly bigger. From all five countries, Italy had the highest difference between the average and year 2020. Likewise, Italy could not protect their eldest - people over 85 who had the largest contribution to the difference.

In Portugal - country in cluster 3 - life expectancy in 2020 dropped in comparison to the average of 2016 to 2019 for both sexes, however, this decline is not as large as for Italy and Czechia and was slightly bigger for females. Portugal did not manage to protect the vulnerable women over 85 years old. Nonetheless, the contribution of the age group 85+ is not significantly higher comparing with other age groups.

In Greece - country in cluster 4 - was only small decrease of life expectancy in 2020 for both sexes in contrast to the average from 2016 to 2019. Age group 85+ had the biggest contribution to the difference for both males and females, however, only with slight lead.

In Germany - country in cluster 5 - life expectancy practically remained the same in 2020 comparing to the average of 2016 to 2019 for both males and females. Germany successfully protected the most vulnerable - the eldest in age group 85+.

Table 1: Average life expectancy from 2016 to 2019 and life expectancy in 2020 and the difference between them for both sexes; Data source: Eurostat

Female	2016 - 2019	2020	Difference
Czechia	82.1	81.3	-0.78
Italy	85.5	84.5	-1.02
Portugal	84.6	84.1	-0.45
Greece	84.1	83.9	-0.22
Germany	83.5	83.5	0.03

Male	2016 - 2019	2020	Difference
Czechia	76.2	75.3	-0.90
Italy	81.1	80.0	-1.10
Portugal	78.4	78.0	-0.38
Greece	79.1	78.8	-0.25
Germany	78.7	78.7	-0.02

4 Discussion

By the end of June 2020, Czechia were not as impacted as other European countries and their strategy to fight Covid-19 pandemic - strict preventive measures (travel ban, border closure, lockdown, face masks) on national level - was considered successful in protecting the health care system from overwhelming. However, the impact on economy and social relationships was severe (Kouřil and Ferenčuhová, 2020). In figure 2, it is evident that regarding mortality impact of pandemic were not significant in spring. During summer 2020, most measures were lifted. At the end of summer with the rising of new cases, face masks were obligatory to wear again and the new strategy to fight pandemic was so called Smart Quarantine - test and trace system that used data from mobile phones. Despite the increase of new cases, protective measures were not as extensive as in spring. One reason might have been local and Senate election in early October (Löblová, Rone, and Borbáth, 2021). The wave in autumn and winter struck more forcefully, this time excess mortality went up dramatically (over 70 % in November). In October 2020, strict protective measures were announced again and blanket testing was declared. This time, restrictions were not nationwide, but local (on administrative districts level) according the pandemic situation there. In spite of these restrictions, health care system was overwhelmed. Life expectancy in 2020 declined, protective measures were not able to protect the elderly. Therefore, in February 2021, second lockdown was re-introduced. In 2021, Czech government set up new strategy to fight the pandemic based on vaccination (Rangachev, Marinov and Mladenov, 2022), by the end of 2021, roughly 64 % of population were fully vaccinated (Mathieu, Ritchie, Ortiz-Ospina, et al., 2021). In spring and summer 2021, most strict measures were lifted first for people who were either vaccinated or recovered from Covid-19 infection, then for everyone. In similar way as the previous summer, impact of the pandemic on mortality was lower during these months. In autumn 2021, the strategy was based on wearing face masks in crowded places, restrictions of big events and intensive vaccine campaign (Greer et al.,2022). The wave in autumn and winter 2021 caused raise of mortality excess to 40 %.

The first European country that experienced uncontrolled transmission of the virus. In February 2021, excess mortality in Italy increased up to 50 %. As a reaction to this first wave, first restrictions were declared in some municipalities in northern Italy (quarantine, school closing, cancellation of public events, ...). In March, protective measures were announced gradually for more and more regions, finally, nationwide lockdown was declared until the beginning of May. Notwithstanding, health care system was overwhelmed (Peralta-Santos, Saboga-Nunes, Magalhães, 2021). In the same was as in Czechia, summer months 2020 were less impacted from Covid-19 (at least mortality). With autumn 2020, second wave arrived, with excess mortality raising to 50 % again. Despite the raise of new cases at the end of the summer, restrictions were imposed (cancellation of events, closing gyms and swimming pools, ...) only in October 2020 (Falkenbach and Caiani, 2021). Italy could not protect the most vulnerable - people older than 85 years old - in 2020 and life expectancy for that year decreased. The strategy to fight pandemic in 2021 was based on vaccination. By the end of 2021, more than 75 % of population were fully vaccinated (Mathieu, Ritchie, Ortiz-Ospina, et al., 2021). In summer 2021, some measures were lifted for those with so called Green Pass - certificate of either vaccination or recover from the illness. In September 2021, Green Passes were made mandatory for all employees. Vaccination campaign in Italy was successful in terms of protecting health care system from overwhelming (Vergallo, et al., 2022) and from drastic impact of the pandemic on mortality - only exception was smaller wave in April 2021 when excess mortality increased up to 20 %.

Portugal declared total nationwide lockdown in March 2020. Despite of that, new cases increased rapidly. Nevertheless, in contrast to the Italian, Portuguese health care system did not get overwhelmed. Perhaps thanks the to knowledge from Italy that was the first European country paralysed by this new virus (Peralta-Santos, Saboga-Nunes, Magalhães, 2021). Due to that fact, in spring 2020, excess mortality raised only up to 10 % in Portugal. Nonetheless, after the end of lockdown, in summer months 2020, new cases surged up and excess mortality increased up to 25 % in July. However, collapse of the health care system did not happen. As a response, strict measures were declared in September 2020 (cancellation of public events, earlier closing tomes of restaurants, ...). In spite of these restrictions, the wave in winter was much stronger than the one at the beginning of pandemic (Violante, Tavares Lanceiro, 2021). Life expectancy in 2020 slightly due to higher mortality in older age, Portugal did not repeat their success from the beginning of the pandemic. In January 2021, excess mortality climbed over 60 %. The same month, second nationwide lockdown was announced. With short gaps, lockdown was in practise until the end of April. The strategy for fight against the virus was vaccination in 2021, Portugal stood out amongst European countries as the most successful with their vaccine campaign (Estrela, et al., 2022), by the end of 2021 more than 83 % of population were fully vaccinated (Mathieu, Ritchie, Ortiz-Ospina, et al., 2021). Excess mortality never increased dramatically for the rest of the year 2021.

In comparison to Italy or Portugal, the raise of new cases at the beginning of the pandemic were not that drastic in Greece. In spite of it, at the end of March, nationwide lockdown was declared until May. Greece was considered successful in its fight against the virus in this phase of the pandemic (Petelos, Lingri, Lionis, 2021). Even though, Greece was popular as a holiday destination during summer months 2020, uncontrolled

transmission of the virus did not happen and excess mortality did not vary significantly from the baseline. In autumn, more stronger wave arrived, with excess mortality increasing to 27 % in November. The same month, second lockdown was announced. With few gaps, lockdown took place until the beginning of May (Politis, et al., 2021), with excess mortality rising to 25 %. In Greece, life expectancy slightly declined in 2020 because slightly unusual higher mortality for people in older age. The strategy for 2021 was vaccination, with roughly 66 % of population fully vaccinated by the end of the year (Mathieu, Ritchie, Ortiz-Ospina, et al., 2021). For the rest of the year, excess mortality three times exceeded 30 % - in August, November and December. The impact of the Covid-19 pandemic on mortality in 2020 was smaller than in Italy, Portugal and Czechia. On the other hand, in 2021, Greece suffered more regarding mortality than Italy and Portugal.

First cases were recorded already in Germany in January 2020, however, no strict restriction were enacted on nation level - some states had less strict measures - until March 2020 when nationwide lockdown was declared. The first phase of the fight against the pandemic, was considered successful (Czypionka, Reiss, 2021). However, with autumn 2020 and winter 2020/2021, dramatic surge of new cases arrived. Nonetheless, health care system withstood the onset of people who needed hospitalization. Excess mortality exceeded 30 % in December 2020. Life expectancy remained the same in 2020, German strategy to protect the most vulnerable - older people - was successful. Second lockdown started before Christmas and took place until April. Since spring 2021, restrictions were not longer enacted by the central government and were in competence of the federal states (Saurer, 2021). In 2021, the strategy for the fight against the virus was based on vaccination. By the end of the year, almost 73 % of population were fully vaccinated (Mathieu, Ritchie, Ortiz-Ospina, et al., 2021). Excess mortality never exceeded 25 % in 2021.

Overall, the impact of the pandemic on mortality depended on many factors. In spring 2020, in the beginning of the pandemic, quick and strict reaction, readiness of the health care system and a little bit of luck were essential. In that matter, Italy suffered the unlucky card being the first European country where uncontrolled transmission of the virus happened, therefore, the restrictions came too late and health care system was not able to to withstand the rapidly surging numbers of patients. On the other hand, Czechia, Portugal, Greece and Germany did learn from Italian example and declared strict measures in March. For autumn and winter 2020, the way the government counter populist voices mattered. In contrast to spring, when most people were afraid of the virus and welcomed the strict restrictions, people were exhausted from the measures in autumn (Greer, King, Massard da Fonseca, 2021). For most countries, the wave at the end of the year 2020 was stronger in terms of both new daily cases and mortality. For 2021, all countries based the fight against the pandemic on vaccination. The successfulness of the vaccination campaign was crucial to the effect of Covid-19 on mortality, as well as when did the process of vaccination truly started. Countries with lower percentage of fully vaccinated population faced stronger waves in terms of the impact on mortality.

5 Conclusion

In every country, Covid-19 pandemic impacted mortality in European countries differently. In the paper, 31 European countries (with available data about excess mortality in Eurostat database) were divided into 5 groups based on the similarities in the development of excess mortality in 2020 and 2021 in comparison to the baseline - average of 2016 to 2019. As it is evident, there are some geographic patterns in the clustering of the countries.

There were three key phases of the fight against the pandemic. Reactions in the form of protective measures were vital regarding the pandemic effect on mortality. The first phase was at the beginning, in spring 2020, the coronavirus was new and it was hard to predict what would be the best way to stop it. The second phase was in autumn/winter 2020, the governments, experts and the public had better understanding of the virus. On the other hand, frustration among people was higher due to unsatisfactory economical situation and impaired social relationships in society, therefore, strict measures were not as popular as in spring. In 2021, the third phase was connected with vaccination campaign. Vaccine might not prevent illness, however, it should prevent unnecessary deaths. From this perspective, vaccine could be the answer for the issue if all these restriction were worth it or not. Protective measures in 2020 gave the expert the time to prepare the vaccine. An in 2021, strict restrictions were not as necessary as the year before because vaccine protected from severe syndromes of the virus and could prevent unnecessary deaths

From the analysis of selected countries, excess mortality was lower in countries that were able to protect the most vulnerable - elderly people, especially those over 85 years old. Many countries suffered from the decline of life expectancy for both sexes due to the Covid-19 pandemic. The impact of the pandemic on mortality cannot be examine without the appropriate context - politic, economic, social, historic and environmental. All of these factors have an influence on protective measures and behaviour patterns of the population.

In the future, analysis could focused more in detail on the geographic patterns and put them in broader social and historic background. In addition to that, interesting results could be find in thorough study focusing on the time when the process of vaccination truly began and how fast the process was.

This paper explores the time period of the years 2020 and 2021. Is the Covid-19 pandemic over? No one can say it with certainly today, only the future will tell. Notwithstanding, analysing the impact of this pandemic could be vital for getting ready for another crisis. The coronavirus emergency showed the weaknesses in Europe - free movement of persons across borders of EU, low capacity in health care systems, etc. But it also revealed the strength - international cooperation to deliver vaccine as fast as possible, high quality of health care, etc. Those are the basic elements that should be considered in the future in the process of preparation for potential disaster.

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