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"Risk of admission to intensive care units due to Covid-19: comparative analysis between European countries"

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Abstract

Background: The Covid-19 epidemic has posed an unprecedented challenge to the European healthcare system, which has had to cope with a much higher than usual demand for hospitalization. This work is devoted to the construction and comparison of risk indicators of admission to intensive care units (ICU) for Covid-19 for eight European countries.

Materials and methods: Using data from July 1, 2020, to January 16, 2022, the weekly percentage of ICU admissions with respect to hospitalizations was calculated and its trend was estimated; tests for differences in means were performed in order to classify the countries into two groups depending on their risk.

Results: The proportion of ICU admissions remained relatively stable in each of the countries. The most southern countries (Italy, Spain and Greece) registered lower ICU risk, but higher hospitalization risk depending on the number of diagnosed cases. Vaccination contributed to reduce hospitalization and death risks, but not ICU risk.

Conclusions: The pressure to the ICU caused by the pandemic has differed between the analysed countries. Mild winters in southern Europe could have worked out well for minor propagation and severity of the virus. Advance in population vaccination rates seems to have reduced the severity of the illness, but the percentage of hospitalizations that require ICU remains unchanged.

JEL classification: I18.

Keywords: Covid-19, Vaccination, Hospitalization, Intensive care units, Europe.

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INTRODUCTION

The disease caused by the SARS-CoV-2 virus was declared a global pandemic by the World Health Organisation on 11 March 2020,[1] generating a devastating impact on public health from the outset. The hospital system in different countries has been put under unprecedented strain by having to assist a very high volume of patients suffering from Covid-19, which has been added to the usual demand resulting from other pathologies.[2]

Hospital intensive care units (ICU) are one of the services that have been most affected by the sudden and unexpected demand for beds to treat severe Covid-19 patients.[3,4] In general, ICU beds are reserved for critically ill patients, who need specialised medical attention and care, high monitoring and life support. The occupancy of ICU beds for pathologies associated with Covid-19 infection is a good indicator of the strain that the hospital system has been under since the start of the pandemic.[5] Unusual demand for ICU care is likely to result in sub-optimal quality of care, affecting medical outcomes.[6-10] Unfortunately, the undersupply of ICU beds at the height of the pandemic has had an impact on the number of deaths due to Covid-19 infection.[5,11]

The healthcare capacity of health systems to care for critical patients differs between countries and depends, among other factors, on their wealth.[12-14] In Europe, there are significant differences in terms of the number of ICU beds per inhabitant, and the spatial accessibility of these units varies greatly between different territories.[15-17]

This article is focused on analysing an indicator of the healthcare stress generated by Covid-19 and, more specifically, by the most severe cases: the proportion of patients admitted to the ICU in relation to the total number of hospital admissions due to the pathology. For a set of eight European countries, a relationship was identified between this indicator and other variables associated with the quality of health care, such as health and hospital expenditure, or the number of ICU beds. The impact of vaccination campaigns on the risk of ICU admission and on other indicators of pandemic intensity, such as the risk of positive diagnosis, hospitalisation or death, was also assessed.

MATERIAL AND METHODS

The main indicator of interest in this study measures the risk of admission to the ICU for pathology associated with Covid-19 infection. This risk is defined as the ratio of weekly ICU admissions compared to total weekly hospital admissions for the pathology.

Data and time period

The data used in this study were obtained from the *European Centre for Disease Prevention and Control*, the European Union agency that collects Covid-19 data for countries in the European Economic Area.(18) Only eight countries for which official registers with complete comparable information were available were selected, namely: Slovenia, Spain, France, Greece, the Netherlands, Italy, Norway and the Czech Republic. The study was conducted for the period from July 1st, 2020 to January 16th, 2022, using weekly data. The first wave of the pandemic occurred in Europe during the first half of 2020.(19) This period was excluded from the analysis because of a shortage of diagnostic tests that limited the detection of positive cases.(20)

Statistical analysis

As is usual when the data to be analysed reflect the evolution of a magnitude over time, the time series was first smoothed using simple moving averages.(21) The trend of the indicators was estimated excluding seasonal and cyclical oscillations, and eliminating part of the observed randomness. The value at each point in time t was calculated as the average value of the r observations prior to t, the observation at t, and the r observations after t. By selecting r equal to 10 periods, it was possible to smooth out the cyclical effect caused by the different waves of the pandemic, which have a duration of approximately 21 weeks or 4.5 months.

Subsequently, statistical hypothesis testing was used to analyse whether the mean weekly proportions of ICU admissions to total hospital admissions (mean risk of ICU admission) are statistically different between each pair of countries. The null hypothesis assumes equality of means between two countries, while the alternative hypothesis states that there are significant differences between these means. A test based on the studentized range, also called the honest significant difference method or HSD test, was performed.[22] This test is especially indicated when the number of pairs of means to be compared is high, as it reduces the possibility of committing Type I errors, i.e. rejecting the null hypothesis even if it is true.[23] As a result, the test allowed the construction of homogeneous groups of countries in terms of the risk of admission to the ICU. The analyses were performed with R software, v. 4.1.2.

RESULTS

Indicators of quality of care

Table 1 presents different demographic and economic indicators related to the quality of health care. In the countries analysed, around 20% of the population was aged 65 or over, with Italy being the most aged (23.2%) and Norway the least (17.5%). Differences in health and hospital expenditure between countries were significant. Analysing the effort made by each country, measured as the percentage of hospital expenditure in relation to gross domestic product (GDP), Norway led the way, followed by the Netherlands, the Czech Republic, France, Greece, Slovenia, Italy and, lastly, Spain. The countries with the highest number of hospital beds and ICU beds per capita were Slovenia, the Czech Republic and Greece.

[TABLE 1]

The European Commission authorised the first Covid-19 vaccine on December 21st, 2020. Figure 1 shows the evolution of the percentage of the population fully vaccinated. Between March and August 2021, there was a very significant boost in the vaccination rate from around 4% in all countries to values between 44.2% (Slovenia) and 66% (Spain). In the middle months of 2021, Norway experienced a delay and subsequent recovery in vaccination speed. At the end of the study period, Slovenia, the Czech Republic and Greece were the countries with the lowest percentage of vaccinated population. The distance with respect to the countries with the highest vaccination rates has remained stable since August 2021.

[FIGURE 1]

Risk of ICU admission

Figure 2 (left) shows the evolution of the risk of ICU admission. Due to the noise observed in the series it was difficult to determine whether the series showed any kind of trend. Using simple 21-week moving averages, a smoothing was obtained that allowed to appreciate their mean values and trend (figure 2, right). The series for most countries showed stable or only slightly increasing behaviour, as in France or Slovenia. In Italy, the shorter length of the series limited the analysis, although a slightly decreasing trend appeared to be recorded, similar to that of Greece. The general pattern in the evolution of the series was of remarkable stability.

[FIGURE 2]

At the same time, there were significant differences between countries (table 2). To determine whether these differences were statistically significant, Tukey's mean difference test was used to obtain two groups of countries in relation to the risk of admission to the ICU. On the one hand, the southernmost countries (Italy, Spain and Greece; group 1) and, on the other, the remaining countries (group 2). The former had a risk between 10 and 13%, significantly lower than the latter, which had values between 17 and 21%. Similar conclusions were obtained by looking at the median, which is more robust than the mean to the presence of anomalous weekly values, such as those observed in the Netherlands and Norway at the beginning of the study period.

[TABLE 2]

Risks of positivity, hospital admission and death

In this section we analysed whether the relative stability observed in the risk of ICU over the period analysed and the presence of two distinct groups of countries was also observed in other indicators. Specifically, the risks of positivity, hospital admission and death were studied. The risk of positivity is defined as the proportion of Covid-19 diagnostic tests that show a positive result. The risk of hospital admission is the ratio of the number of patients diagnosed with coronavirus to the number of hospital admissions. Finally, the risk of death is calculated as the ratio between the number of deaths attributable to coronavirus infection and the number of hospital admissions due to coronavirus infection. In all cases, weekly aggregate data were used. Figure 3 shows the trend estimated using moving averages for these three risks.

[FIGURE 3]

The risk of positivity peaked at the end of 2020, and then started to decrease steadily until week 33 of 2021, when an upturn was observed. Given that moving averages were analysed, this decrease would coincide in time with the start of the vaccination programme. Differences between countries were particularly high throughout 2020 with the highest values in Slovenia and the Czech Republic. In turn, the risk of hospitalisation was stable until week 15 in 2021. Thereafter, it clearly decreased, although some slowdown was observed in the last weeks. Greece showed the highest mean values, and Norway and the Netherlands the lowest. The risk of death showed a similar pattern to the risk of positivity with a clear increase until the first weeks of the year 2021; thereafter it decreased, although at the end of the period studied a change in trend seemed to be discernible. Italy stood out notably as the country with the highest risk of death, although the distances between the countries as a whole narrowed at the end of the period analysed.

Unlike the risk of ICU admission, the three indicators analysed in this section were not stable over time. There was also no discernible pattern of behaviour differentiating between the southern countries and the rest of the countries.

CONCLUSIONS

The high values of the risk indicators analysed show that the Covid-19 pandemic has forced the European healthcare system to face an unprecedented healthcare challenge. Although there were periods of higher or lower risk of hospitalisation throughout the different waves, this article shows that the risk of a hospitalised patient being assigned to an ICU bed has remained relatively stable for each of the countries studied throughout the pandemic period analysed.

The rapid growth of the vaccination rate does not seem to have lowered the risk of ICU admission. However, the risks of positivity, hospitalisation and death show a favourable trend for most of the year 2021. These results suggest that vaccination has contributed to mitigating the risk of infection and hospitalisation.[26] Thus, it can be concluded that immunity from vaccination decreases the likelihood of hospital admission, although the ratio of people admitted requiring ICU care remains constant. However, the lower risk of death observed after the start of the vaccination period seems to indicate that the prognosis of patients admitted to the ICU is less severe.

There is no evidence that the different variants of Covid-19 detected in Europe throughout the pandemic have caused variations in the risk of admission to the ICU. To date, according to the US Center for Disease Control and Prevention, the two most dangerous variants have been delta, due to its greater severity, and omicron, due to its high transmissibility.[27] The first cases of the delta variant appeared at the end of February 2021 and, in June 2021, it was dominant in Europe.[28] The omicron variant appeared in Europe at the end of November 2021 and was considered dominant by January 2022.[29] Some work suggests that this variant has a lower risk of hospitalisation and death than the delta variant.[30] It is difficult to determine the role of each of these variants in the change in trend observed in the indicators of risk of positivity, hospitalisation and death in the second half of 2021.

The analysis of the Covid-19 impact shows that the countries studied fall into two clusters with significant differences in the proportion of hospital admissions to ICU: the southernmost countries (Italy, Spain and Greece), which are at lower risk, and the rest of the countries. No clear association was found between this lower ICU pressure and other indicators of good quality of care, such as higher hospital expenditure relative to GDP. These three Mediterranean countries are, together with Slovenia, the ones with the lowest percentage of their GDP spent on health and hospital expenditure. This finding, together with Roemer's Law, which states that an available hospital bed is an occupied bed,[31,32] could suggest that in these countries there is a deficit of ICU beds, which would make it difficult to provide intensive care to certain patients who might require it. However, countries such as Greece have a high availability of ICU beds, but a low risk of admission to these units. At the opposite extreme, Norway and the Netherlands report a lower number of ICU beds, but a high risk of admission to these units. This may suggest that factors other than quality of care may have a beneficial effect on the severity of illness. In this regard, some studies point to the geographical location of countries, and more specifically to their latitude.[33] Because of the negative correlation between environmental temperature and other factors such as incidence, mortality and difficulty of recovery, mild winters in Mediterranean countries may curb the virulence of SARS-CoV-2.[34]

A certain inverse relationship between risk of hospitalisation and risk of ICU admission is also detected. Italy, Spain and especially Greece show high values for risk of hospitalisation accompanied by low values for risk of ICU admission. The opposite is true for France, the Netherlands and Norway. In Spain and Italy, this could be evidence that the rapid increase in vaccination rates contributed to lowering the severity of symptoms.[35] The exception would be the Czech Republic and, to a lesser extent, Slovenia, which show both high values for risk of hospitalisation and ICU admission. It should be noted that these two countries have the lowest percentages of the population vaccinated with the full regimen.

Some studies point out that the percentage of positivity is an inverse indicator of the effort made by the country to detect people infected with the virus.[36] The different risk of positivity does not explain the differences in the risk of ICU. Countries with similar values for this indicator, such as Spain and the Netherlands, show very different behaviours in the risk of ICU hospitalisation. Finally, there is no association between the risk of mortality and the risk of ICU admission. Spain and Greece, in contrast to Italy, show low values for the risk of death; however, all three countries show a low percentage of patients admitted to ICU. This could be an indicator of differing quality of care.

This study is not exempt from limitations that should be pointed out. There is no longitudinal information available on patients affected by Covid-19, which prevents the indicator of risk of admission to the ICU from responding to the probability of a typical patient being admitted to this unit. This is partially corrected by calculating moving averages. On the other hand, the concept of ICU bed may vary from country to country, as each country has its own regulations on the requirements demanded of these units. This does not affect the conclusions obtained for each country, but it could have some influence on the comparability of indicators between countries.[25] On the other hand, the need to collect health data immediately at the start of the pandemic could have led to discrepancies between the standards for recording information in the different countries.

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Table 1. Demographic and economic indicators for the European countries studied, 2018-2021.

	Population, million inhab. (2021)	Population 65 years and older, %. (2020)	GDP per capita, euro (2020)	Health expenditure relative to GDP, %. (2019)	Hospital expenditure relative to GDP, %. (2019)	Hospital beds per 100,000 inhab.[a]	ICU beds per 100,000 inhab.[b]
Slovenia	2,11	20,2	19.720	6,7	3,0	413,4	25,6
Spain	47,33	19,6	22.350	6,1	2,5	249,7	10,4
France	67,36	20,4	30.610	8,0	3,4	304,1	16,4
Greece	10,68	22,3	16.170	5,3	3,3	363,5	17,5
The Netherlands	17,41	19,5	40.160	7,7	3,6	268,8	7,0
Italy	59,64	23,2	24.900	6,8	2,8	258,8	8,7
Norway	5,39	17,5	68.590	8,7	5,2	313,4	5,4
Czech Rep.	10,70	19,9	17.340	7,6	3,6	408,0	43,2

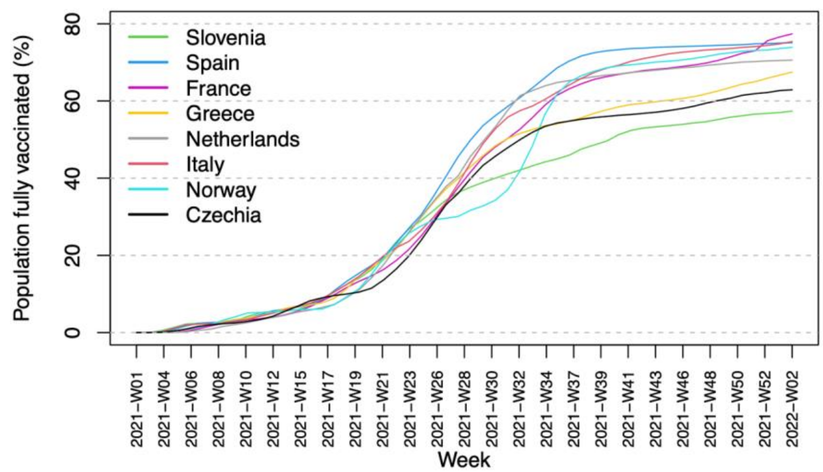
Source: Eurostat (2021)[24]. [a] Most recent data available between 2018 and 2021. [b] OECD (2021),[25] except Slovenia[15]; latest available data between 2019 and 2021. GDP = Gross Domestic Product; inhab. = inhabitants; ICU = Intensive Care Unit.

Table 2. Percentages of weekly hospital admissions that are assigned to ICU in the countries studied, and classification of countries into groups according to their average percentages. Period from the beginning of 2021 to the second week of 2022.

Country	Mean	Variation coefficient	25% Percentile	Median	75% Percentile	Group
Slovenia	17,6	32,9	14,1	17,9	21,8	2
Spain	10,5	19,0	9,2	10,2	12,0	1
France	20,4	19,1	16,4	22,0	23,5	2
Greece	10,0	22,0	8,8	9,9	11,2	1
The Netherlands	21,0	58,1	16,1	17,3	21,2	2
Italy	12,9	19,4	11,3	13,3	14,4	1
Norway	18,0	43,3	13,1	17,1	23,0	2
Czech Rep.	20,3	20,2	17,5	20,4	22,3	2

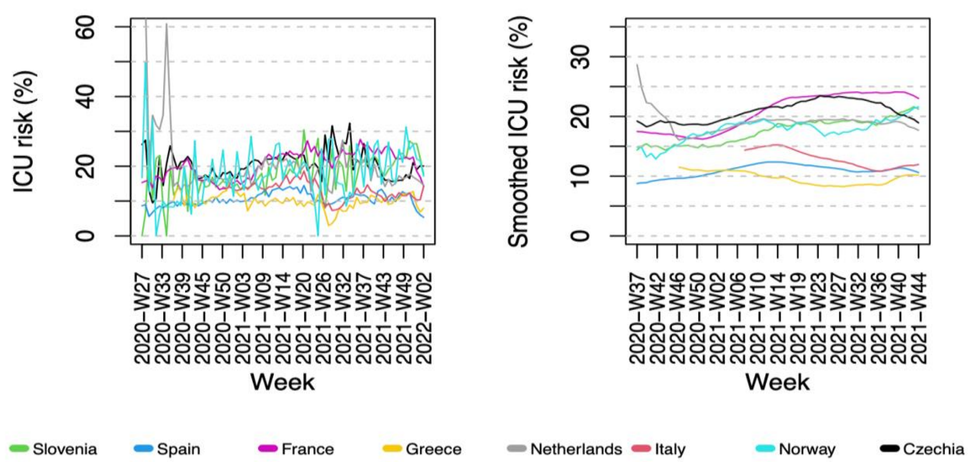
Source: Own elaboration based on data from the European Centre for Disease Prevention and Control, European Union. ICU = Intensive Care Unit.

Figure 1. Evolution of the full schedule vaccination rate for the countries studied. Weekly data from January 1st, 2021 to January 16th, 2022.



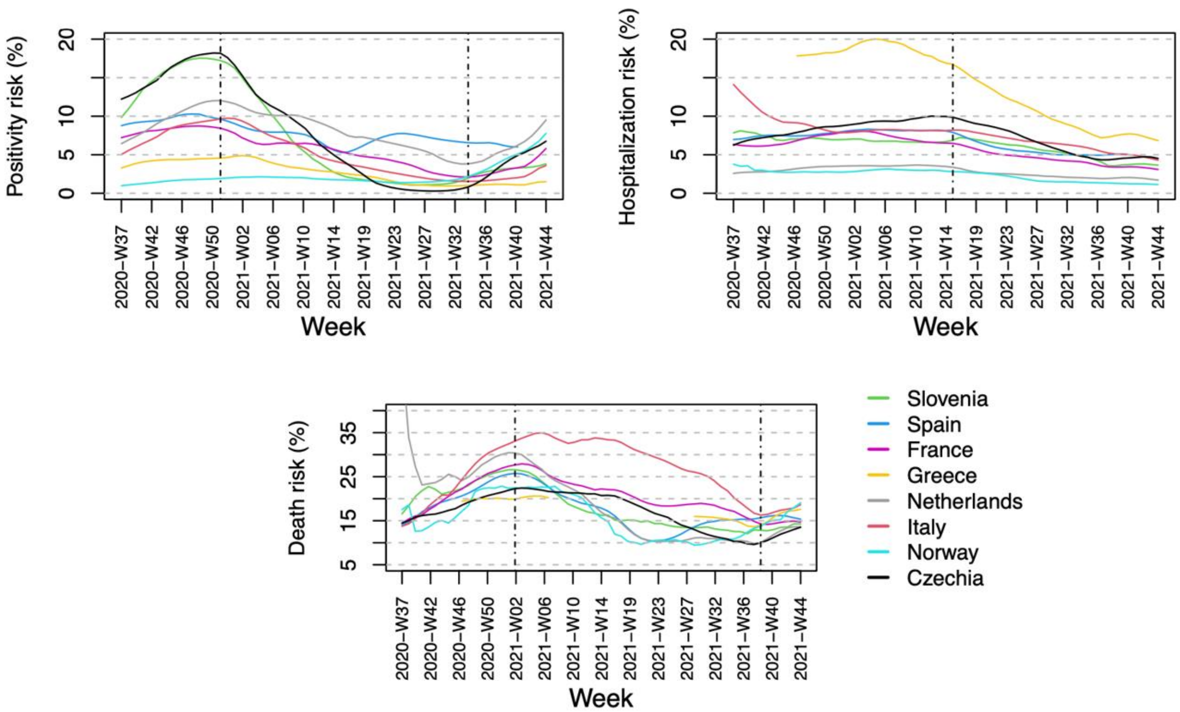
Source: Own elaboration based on data from the European Centre for Disease Prevention and Control, European Union. Week "k" of the corresponding year is denoted as "Wk".

Figure 2. Risk of ICU admission for the countries analysed: original series (left) and smoothed by 21-observation moving averages (right). Weekly data from July 1st, 2020 to January 16th, 2022.



Source: Own elaboration based on data from the European Centre for Disease Prevention and Control, European Union. ICU = Intensive Care Unit. Week "k" of the corresponding year is denoted as "Wk".

Figure 3. Smoothed risks of positivity, hospital admission and death for the countries studied. Moving averages of 21 observations. Weekly data from July 1st, 2020 to January 16th, 2022.



Source: Own elaboration based on data from the European Centre for Disease Prevention and Control, European Union. Week "k" of the corresponding year is denoted as "Wk".

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