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Unbiased Indicators of Hospitals Occupancy during the COVID-19 Pandemic

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ABSTRACT

Most public health agencies in regions or countries report the SARS-COV2 disease situation on a daily basis based on cases confirmed by various diagnostic tests. They also report other indicators such as deaths, admissions and intensive care admissions as supplementary information. However, due to the lack of uniform criteria and the adoption in each hospital of ad hoc measures to deal with the increase in cases, epidemiologic curves based on confirmed infections do not allow comparison between regions or countries analyzed. We e propose a simple composite indicator in order to measure health occupancy using a fixed reference system. This indicator makes it possible to know and compare the state of health systems, without the deviation in the information produced by the adoption of individual measures that aim to adapt hospitals to the daily evolution of the epidemic. Seventeen Spanish regions are analyzed in the first six months since the declaration on March 11, 2020 by the World Health Organization (WHO) where the new disease caused by the coronavirus 2019 (COVID-19) can be characterized as a pandemic. The data have been obtained from the Ministerio de Sanidad, Consumo y Bienestar Social and from the official COVID-19 data page in Spain. Finally, R software has been used for data manipulation and methodology.

Keywords: Composite index, COVID-19 and Health policies.

JEL Classification: C02, I140, I180

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Indicadores no Sesgados de la Ocupación de los Hospitales durante la Pandemia de COVID-19

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RESUMEN

La mayoría de los organismos de salud pública de las regiones o países informan diariamente de la situación de la enfermedad del SRAS-COV2 basándose en los casos confirmados mediante diversas pruebas diagnósticas. También comunican otros indicadores como las muertes, los ingresos y las admisiones en cuidados intensivos como información complementaria. Sin embargo, debido a la falta de criterios uniformes y a la adopción en cada hospital de medidas ad hoc para hacer frente al aumento de casos, las curvas epidemiológicas basadas en las infecciones confirmadas no permiten la comparación entre las regiones o los países analizados. Proponemos un sencillo indicador compuesto para medir la ocupación sanitaria mediante un sistema de referencia fijo. Este indicador permite conocer y comparar el estado de los sistemas sanitarios, sin la desviación en la información que produce la adopción de medidas individuales que pretenden adaptar los hospitales a la evolución diaria de la epidemia. Se analizan diecisiete comunidades autónomas españolas en los primeros seis meses desde la declaración el 11 de marzo de 2020 por parte de la Organización Mundial de la Salud (OMS) de la nueva enfermedad causada por el coronavirus 2019 (COVID-19) como pandemia. Los datos se han obtenido del Ministerio de Sanidad, Consumo y Bienestar Social y de la página oficial de datos de COVID-19 en España. Finalmente, se ha utilizado el software R para la manipulación de los datos y la metodología.

Palabras clave: Índice compuesto, COVID-19 y Políticas sanitarias.

Clasificación JEL: C02, I140, I180

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1. Introduction

Most of the public health agencies in regions or countries report daily the status of the disease caused by SARS-COV2 based on cases confirmed according to the diagnostic tests. They also report other indicators such as deaths, admissions and intensive care admissions as supplementary information. However, epidemiological curves based on confirmed infections are sometimes confusing, and in many cases are not representative of the disease situation, nor do they allow comparison between regions or countries analyzed (Chua et al., 2020). Even with the introduction of vaccines, this measure---number of reported infections---, is used as a reference for policy decisions that have a direct impact on the health, social and economic environments.

Four factors are essential to explain the low reliability of the observed values for indicators based on the number of confirmed cases. The first is quantitative. The number of diagnostic tests varies by region or country of study, resulting in widely disparate comparative rates. In addition, countries or regions have increased testing capacity, resulting in more and more asymptomatic people being tested, which directly affects the estimate of the probability of a person testing positive. The second factor is qualitative. The different types of tests, either ‘’nucleic acid amplification test for viral RNA'' or ‘’antibody detection'' have associated Type I and Type II errors (commonly referred to as false or positive or false negative) that cause the count of confirmed cases to move in very wide bands (Patel et al. ;2020; Surkova et al. 2020) . For instance, Lisboa et al. (2020) found that there exist weaknesses in the evidence base for serological tests for COVID-19. Thus, oscillations in large and significant samples could reflect very different situations. The third factor is associated with the method in which diagnostic tests are carried out. The results are different if the sample chosen is random, the result of a traceability follow-up, or carried out on a given group. Thus, the different criteria chosen by health authorities in different regions or countries provide data that are not comparable and therefore do not allow the establishment of homogeneous thresholds on the basis of which decisions can be made. Finally, Mateo-Urdiales et al. (2021) shows that the risk of infection, hospitalization and death from SARS-CoV-2 decreases gradually and substantially in vaccinated individuals. Therefore, the incidence rate appears to be an increasingly fuzzy indicator, and consequently, it does not allow estimating future health pressure.

Consequently, it is crucial to provide indicators that allow for a more efficient monitoring of the disease from a more uniform approach. According to Chua et al. (2020), this indicator should be impervious to the dysfunctions listed above. Health authorities make decisions based on several criteria, although the most important is to avoid the collapse of the health system. In this sense, the indicator must emphasize the pressure that is exerted on it, without undermining the cumulated incidence (CI), but having this issue as its backbone. Since January 31, 2020---the day the Ministry of Health announced the first case of COVID-19 on the island of La Gomera (Canary Islands)--, many criteria have been taken to adapt to the situation caused by this disease. Under Royal Decrre 463/2020 , the Spanish government decreed a state of alarm, limiting citizens' freedom of movement to certain cases and ordering the closure of most shops and all places of leisure, education and culture. The Ministry of Health assumes sole command of all regions until 21 June, when the last state of alarm ends, de-escalation is complete and the whole country enters the ”new normal", after 99 days of national emergency. However, data on new infections, hospital admissions, deaths and other information on the health situation continue to be reported by the regions, with significant divergence in the meaning of the indices used, and the reliability of their computations. Casal (2020) published incidences of the data provided by the Ministry of Health and the Carlos III Institute from the beginning of the Pandemic until the end of the de-escalation corresponding to the first wave.

Responsibilities for health in Spain are transferred to the autonomous regions (CCAA), except in Ceuta and Melilla (Spanish cities in North Africa). The State has only exclusive powers over foreign health, the strategic bases and general coordination of health, legislation on pharmaceutical products, basic legislation and the economic regime of the Social Security. The rest of the matters relating to health services are the responsibility of the CCAA regions. Although initially the transfer of healthcare competences did not generate an increase in regional inequalities in results and investment, the disparity in healthcare spending has been explained by social and demographic differences and the effects of geographical dispersion (Costa-Font and Rico, 2006). Some studies provide evidence that SARS-CoV-2 virus transmission is not homogeneous in Spain between Spanish regions. Mobility, economic structure, migration and overall regional health status are strongly associated with COVID-19 outcomes . In addition, differences in population characteristics, health policy measures and other specific factors show divergences in pandemic control between regions. On the other hand, the role of the private health sector in each region is very different, and there is no common strategy to assess and prioritize through needs the involvement of this actor in public health (López-Valcarcel and Barber, 2017).

This paper analyses hospital occupancy in Spain using the information officially provided by the governments of its 17 autonomous regions[1]. The aim of the paper is to propose new ideas for the definition of stable indices, explaining why and how they can serve to fix the information and make it available to the public without deviations. The main idea is that these indices have to be comparable, and have to refer to the normal situation of health systems, and not to the situation created by adding new improvised resources that have been created rapidly according to the day-by-day needs. The reason is that these newly added resources are often of “low quality” in a certain sense---compared to the structural resources that hospitals possess---, and their adoption is detrimental to the normal functioning of other hospital services outside the epidemic. Thus, calculations based on these new and daily changing resources are very often confusing and give an impression of normality that is not at all correct, instead of giving the objective information that is needed, for example, for decision-making. The paper is organized as follows, Sect. 1 provides a brief introduction and related literature. Material and methods are introduced in Sect. 2. Sect. 3 contains the results of the study. Finally, conclusions are drawn in Sect.4.

2. Materials and Methods

2.1. Materials

The dataset has been compiled from different sources. New data are published daily, and changes are also updated daily according to the publication schedule and rhythm of the Ministerio de Sanidad, Consumo y Bienestar Social (2021). Also, data on the number of hospital and intensive care beds, both public and private, are obtained from the portal of the Ministerio de Sanidad, Consumo y Bienestar Social (2021). It should be noted that this information is not provided in accessible and reusable formats. Due to this anomaly, the daily situation series of the SARS-CoV-2 coronavirus disease (COVID-19) have been obtained from Casal (2020). This dataset uses the official data available in the Documentation and Data tab of the webpage Situation of COVID-19 in Spain (Red Nacional de Vigilancia Epidemiológica , 2021) of the Instituto de Salud Carlos III (2021).

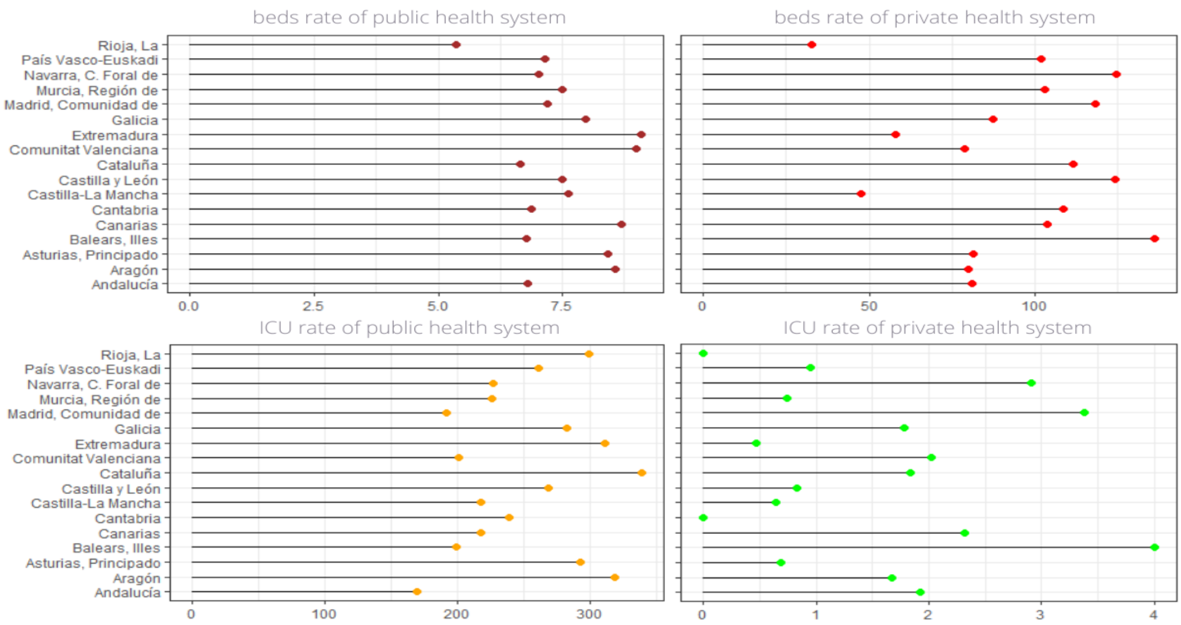
Disaggregated Data from Spanish regions

The previous economic crisis that started in 2008 generated significant changes in the health care system, both nationally and regionally, as a result of economic cuts imposed from Brussels to adjust the economic deficit (Gallo, 2013). These changes have added to regional policies that have either supported or improved the public health system. Figure 1 shows the significant differences that exist among Spanish regions. The upper left figure shows beds rate of public health system and the upper right the beds rate of private health system per 100.000 habitants. The bottom left shows the ICU rate of public health and the bottom right the ICU rate of private health system per 100.000 habitants.

[1] Spain is a composite, decentralized nation state currently divided into 17 autonomous regions, each comprising one or more provinces, and two autonomous cities (Ceuta and Melilla). With the exception of the last two, the rest of the regions have transferred their competences in the health sector. Ceuta and Melilla are directly dependent on the Ministry of Health.

These ``health inequalities"[2] also lead to disparities in the care of the COVID-19. The imbalances between regions directly affect the strength of each system to cope with the disease. These disparities must be taken into account, as will be discussed below, to provide a more realistic indicator of the disease situation. Due to the existing inequalities in health indicators and also to the heterogeneity in data collection and analysis between CCAA, it is not possible to have a realistic description to compare the situation caused by COVID-19.

Figure 1 Rate health variables per 100.000 population.



Source: Ministerio de Sanidad, Consumo y Bienestar Social.

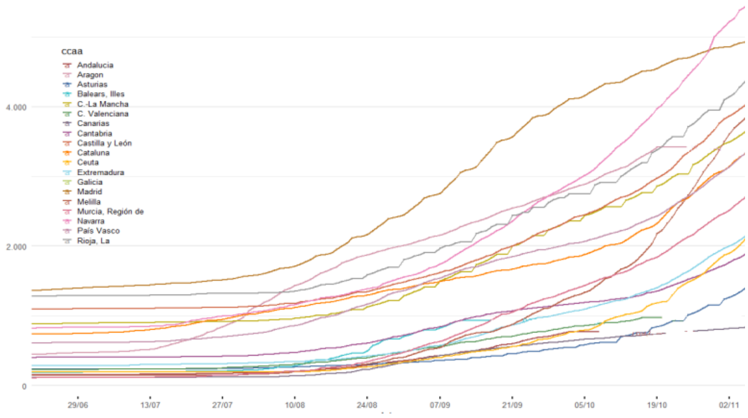
Figure 2 shows the data of COVID-19 cumulative incidence (CI in the Spanish statistics) per 100.000 inhabitants distinguishing by CCAA since the end of the alarm state until November 5, 2020. The behavior of the curves shows some divergences. The regions of Madrid and Aragon have a higher cumulative incidence rate. The other regions have a similar cumulative growth, with some exceptions. However, although the positive cases detected represent a lower level of the real number of infected, according to the four factors explained in the Introduction, we find that the different measurement criteria, together with the differences between the different health systems, do not allow comparisons between regions based on the incidence rate.

However, these divergences are not only seen in the indicators of cumulative incidence rate per 100.000 inhabitants. The case fatality risk (CFR), is a measure of disease severity, which is computed as the proportion of deaths from a certain disease compared to the total number of people diagnosed with the disease for a particular period. Mortality statistics in Spain are defined as those deaths of patients testing positive for SARS-CoV-2 by RT-PCR, irrespective of pre-existing diseases that may have caused the death. Figure 3 left, shows the CFR index by CCAA. The divergence between the CFR index of the regions is very accentuated in the cases of Murcia, Canarias and Andalucía having the smallest values, and Catalonia and Castilla la Mancha having the highest. According to Onder et al. (2020), the demographic characteristics of the population in the Spanish regions could explain the divergence obtained in the CFR. On the other hand, Perone (2021) shows positive and significant relationships between CFR and population age. Specifically, this increase is directly proportional to the age range

[2] According to Braveman (2006), the term of ``health inequalities or disparities'' refer to a subset of differences due to social values, including ethical concepts of distributive justice.

analyzed from 70 years onwards. It is to be expected that older populations are more vulnerable to the disease and that, consequently, the CFR is higher. For Spanish regions, the proportion of people over 65 years of age by autonomous regions shows significant variability. The region of Murcia has the lowest percentage (16.10%), while the Principality of Asturias has the highest percentage (26.46%). The median in Spain is 20.68% and the average is 20.25% (Table 1). We compute Kendall's rho statistic to estimate a rank-based measure of association between the CFR and the data corresponding to the percentages for the over-65s. For Kendall's test, the alternative hypothesis is true tau is not equal to zero. An exact p-value is computed with p-value=0.5976 and estimated tau equal to 0.10. Therefore, we find evidence of no correlation.

Figure 2. COVID-19 infection cumulated rate between June 20 and November 5, 2020 per CCAA.



Source: Casal (2020)

Table 1. Proportion of people over 65 years of age by autonomous regions

Min.	1st. Qu.	Median	Mean	3rd. Qu.	Max.
16,10	18.08	20,14	20,68	22,67	26,46

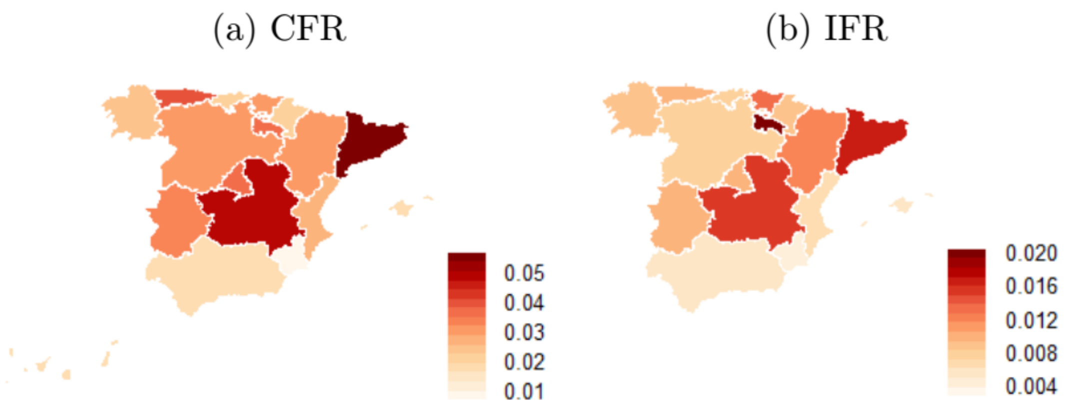
Source: Instituto Nacional de Estadística (INE)

On the other hand, the indicator called infection case fatality rate (IFR) represents the proportion of deaths among all infected individuals, including all asymptomatic and undiagnosed subjects. According to the Instituto de Salud Carlos III (2020) corresponding to the fourth round, which provides a large population-based longitudinal sero-epidemiological study, we are able to compute the IFR index for CCAA (Figure 3 right). The objectives of this study were to estimate the prevalence of SARS-CoV-2 infection through the determination of antibodies against the virus in the CCAA, carried out between 16 and 29 November with a total of 51.409 people. As can be seen, the index IFR also generates large discrepancies between the regions analyzed. La Rioja, Catalonia and Castilla la Mancha have the highest percentages. On the other hand, the Canary Islands, Murcia and Andalucía are the regions with the highest percentages. All these disparities exhibit heterogeneity across the regions analyzed. Keynon (2020) suggests that Spanish regions with more rapid and prolonged SARS-COV2-generated disease spread have higher IFR. These results are consistent with the fact that controlling the epidemic early would prevent regional health stress. As a consequence, mortality, CFR and IFR would be reduced, but, from our point of view, more information would be needed to confirm these arguments.

The stress of different health systems has side effects that result in excess mortality among their inhabitants. Figure 4 shows the annual change in cumulative deaths 2020/2019 by regions for cumulative deaths from week 52 of 2019 to week 53 of 2020. When the occupancy rate exceeds a certain threshold, the health care managers suppress the non-COVID-19 activity. These measures lead to delays in the care of patients with other pathologies, in some cases resulting in a worsening of their illnesses. The impact of such measures has not yet been accurately estimated. However, note that in

Spain, cancer alone is one of the main causes of morbidity and mortality, with the number of deaths for 2018 at 112.714. This disease accounts for 26.4 percent of deaths and is the second leading cause of death in Spain in 2018 (INE). Currently, it is estimated that 20% fewer cases have been diagnosed than in 2019 (Red Española de Registros de Cáncer , 2020). Table 2 shows the significant divergences between the CCAA with respect to the indicators analyzed in this paper until 5 November 2020. The first indicator shows data on the population in the analyzed regions in 2019, the second indicator (Cum_cases) shows data on the number of cumulative COVID-19 positive cases up to November 5, 2020. The third indicator (Cases_popu) shows the percentage of positives out of the total population, the fourth (Prevalence) the estimated percentage of the cumulative or overall prevalence, i.e. the percentage of people who have had or currently have anti-SARS-CoV-2 IgG antibodies from February to November 2020, the fifth and sixth the CFR and IFR indicators. Finally, the seventh is the percentage difference in excess mortality between 2020 and 2019.

Figure 3. CCAA rate health variables



Source: Casal (2020)

The indicator values CFR, IFR, excess of mortality are the result of several factors. The intensity of disease spread in each region in the period analyzed represents one of the reasons for the excess of these indicators. However, other factors such as the saturation of the health system may have played another important role in explaining the variability of these indicators. The measures adopted as a result of health policy decisions have a significant influence on mitigating this stress. Therefore, the methodology for measuring health pressure must be clear and homogeneous.

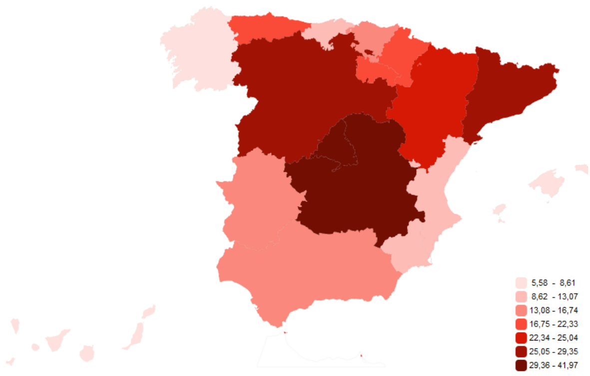
Karlinsky and Kobak (2021) collect data for 103 countries out of 200, with particularly low coverage in Africa, Asia and the Middle East, for which the sum of excess mortality estimates results in 4.0 million excess deaths. In particular, Cronin and Evans (2021) found that 13% of excess mortality in the US in 2020 is due to non-COVID-19 causes. Empirical evidence suggests that many non-COVID-19 deaths are generated by the shutdown of the economy, efforts to increase social distancing to combat the virus in addition to massive decline in the use of health care throughout the pandemic. Teixeira da Silva and Tsigaris (2020) found evidence that testing policies, delaying policies for international travel restrictions, public information campaigns increased the fatality rate across 121 nations. In the case of Spain, Figure 4 shows the excess mortality in absolute numbers by region in 2020 compared to the pre-pandemic year 2019. A more pronounced variation is observed in the central regions and Catalonia, with the coastal regions accounting for the fewest excess deaths (INE 2021).

Table 2. Data by CCAA

CCAA	Population	Cum_cases	Cases_popu	Prevalence	CFR	IFR	Diff.Deaths
Andalucía	8.414.240	179.750	0,021	7,10%	0,016	0,005	13,18%
Aragón	1.319.291	65.372	0,050	11,7%	0,029	0,012	25,04%
Asturias	1.022.800	15.877	0,016	6,10%	0,038	0,001	19,28%
Balears, Illes	1.149.460	20.723	0,018	6,30%	0,018	0,005	8,61%
Canarias	2.153.389	12.964	0,009	3,80%	0,016	0,004	5,58%
C.La Mancha	2032863	76860	0,038	12,60%	0,049	0,015	34,95%
C. León	2.399.548	103.628	0,043	16,10%	0,053	0,016	28,53%
C. Valenciana	5.003.769	72.661	0,015	5,70%	0,027	0,007	13,07%
Extremadura	1.067.710	24.268	0,023	8,00%	0,034	0,010	16,74%
Galicia	2.699.499	42.533	0,016	4,50%	0,024	0,008	6,28%
Madrid	6.663.394	330.602	0,050	18,60%	0,036	0,010	29,35%
Murcia, R.	1.493.898	44.210	0,030	6,10%	0,009	0,005	13,07%
Navarra	654.214	36.540	0,056	14,30%	0,012	0,008	22,33%
País Vasco	2.207.776	78.784	0.036	8.20%	0.029	0.012	13.36%
Rioja, La	316.798	14.398	0.045	8.20%	0.034	0.019	21.44%

Source: Instituto Nacional de Estadística and own elaboration.

Figure 4. Annual change in cumulative deaths 2020/2019



Source: Instituto Nacional de Estdística (INE)

Estimación del número de defunciones semanales

2.2. COVID-19 occupation indicator

On 16 July 2020 the ACs together with the central government approve the Early Response Plan in a COVID-19 pandemic control scenario which aims to respond to the challenges caused by COVID-19. The Plan sets out the preparedness and response capabilities to be ensured in case of increased SARS-CoV-2 transmission. Following the recommendations of the Council of Europe, the European Centre for Disease Control established a 14-day cumulative incidence threshold of 25 cases per 100,000 population to consider that the risk is beginning to increase, and an upper limit of 150 cases per 100,000 population to consider that the risk is very high. For Spain, an additional incidence threshold above 250 per 100,000 is set to indicate situations of extreme risk where additional actions are required if those applied with incidences above 150 per 100,000 do not control transmission.

This action plan defines the main indicators for risk assessment which are separated into two blocks and establishes thresholds to determine whether the risk is low, medium, high or very high. A first block with indicators that assess the level of transmission based on the incidence rate and a second block with indicators that measure the level of utilization of care services by COVID-19. The definition provided to measure the alert levels establishes for the different risk levels the fulfilment of at least one indicator in each block.

On the one hand, hospitals have had to adapt to the circumstances brought about by COVID-19. New ICUs, additional beds, ventilators, medical staff, etc. had to be created. Therefore the occupancy level is variable and therefore it is impossible to know what the real occupancy level is. On the other hand, the increasing capacity of a hospital to respond to the demand of COVID-19 patients has been contracting the system's capacity to care for non-COVID-19 patients.

On the other hand, according to Chua et al. 2020, the incidence rate can give a signal of what might happen, however, it is an indicator that depends on many factors and the outcome can be diffuse.

We provide an indicator to compare the real state of health pressure between regions or countries, which would be useful for political decision-making. The homogenization of a methodology would give more clarity and transparency to the methods of measurement and therefore, a more realistic view of what happens in an epidemic. For its construction, we adopt the following three assumptions:

1. Capacity thresholds have to be fixed for each region throughout the analysis period.
2. The indicator has to be comparable across regions and at different points in time.
3. The indicator has to take into account the hospital occupancy of non-COVID-19 patients.

Let us define now the proposed index in mathematical terms. We write R^+ for the set of positive real numbers. Let b_{it} be the number of occupied beds and c_{it} the number of occupied ICU beds the day $t \in \{1, \dots, T\}$ in region $i \in \{1, \dots, n\}$. Let $\tilde{b}$ and $\tilde{c}$ be the maximum capacity of these units before the onset of the pandemic. We define the function $f: R^+ \to [0,1]$ as

$$f(x) = 1 - \begin{cases} \dfrac{\tilde{x} - x}{x} & if\ \tilde{x} - x > 0 \\ 0 & if\ \ \tilde{x} - x < 0 \end{cases}$$

$$\tilde{x}$$

where $\tilde{x}$ represents $\tilde{b}$ or $\tilde{c}$ depending on whether we are measuring ICU occupancy or hospital beds occupancy. According to this, $f\left(b_{\{it\}}\right)$ provides the occupancy of hospital beds by COVID-19 patients taking into account maximum values $\tilde{b}$ before the epidemic. On the other hand, $f\left(c_{\{it\}}\right)$ gives the occupancy of ICU beds by COVID-19 patients taking into account maximum occupation $\tilde{c}$ before the epidemic. There are several reasons why we consider these thresholds fixed. Hospital bed occupancy has varied according to the needs imposed by the pandemic. The care of patients with pathologies other than COVID-19 is compromised, and non-urgent surgical activity unrelated to COVID-19 is suspended. As shown in Figure 4, this leads to excess mortality in the population. Hospital pressure has serious side effects on healthcare systems. Even if the capacity is modified to meet the needs generated by the SARS-COV2 at a given point in time, the baseline should be set in advance. Regarding to this, the expansion and contraction in the number of beds offered by each region does not make it possible to know at any given moment the level of occupancy of the regions analyzed, since the reference system is not fixed. Because hospital beds and ICUs are communicating vessels, the transfer of patients from one unit to the other is continuous in both directions. Therefore, overcrowding of either leads to stress problems in the hospitals and by extension in the regions analyzed. The maximum function between the two indicators is used to capture the extreme cases where one of the two indicators is saturated and the other is not. In connection with the above, we define the COVID-19 occupation indicator (COI) as follows: fixed the region $i \in \{1, .., n\}$ and the day $t \in \{1, \dots, T\}$, the COI is given by

$$COI = \max\{f(b_{\{it\}}), f(c_{\{it\}})\}$$

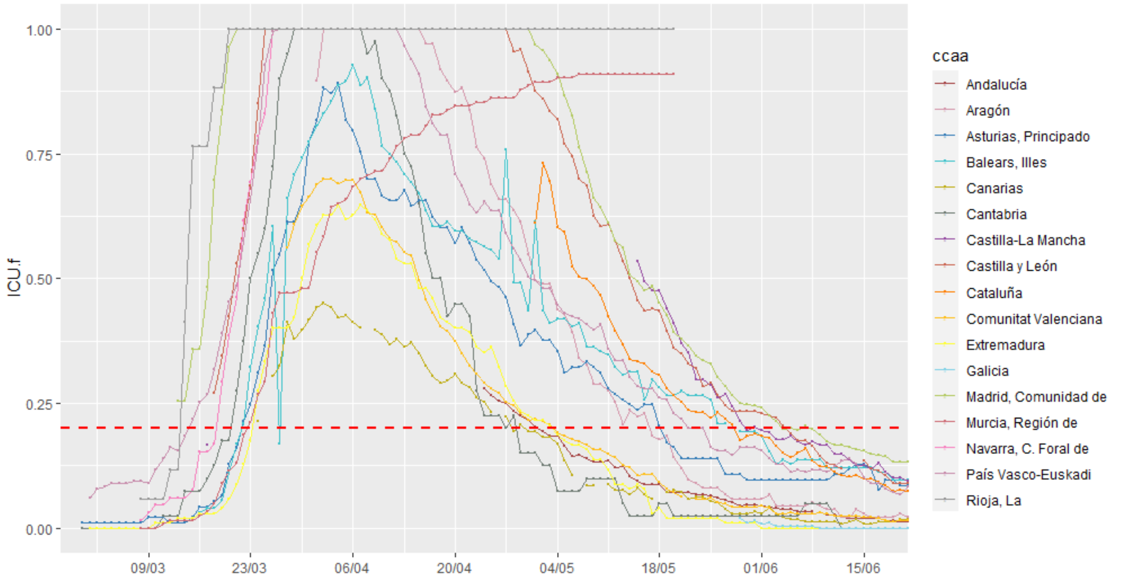
Although cumulative incidence at a time interval T may be a good indicator to anticipate future hospital pressure, it is not a good indicator for comparison. The simple methodology proposed in this paper is designed to harmonize the measurement of hospital and ICU bed occupancy across all Spanish regions. Indeed, this homogeneous measure allows comparison over time and between regions.

3. Results

We analyze the behavior of this index in the period under study. Figure 5 shows the hospital ICU occupancy between February 2th and June 21th among all regions analyzed. Dashed horizontal red line represents the average number of ICU public and private beds available in pre-pandemic periods. From mid-March to the end of May, all regions exceeded available capacity. This meant that new spaces had to be made available to increase hospital capacity to cope with the demand generated by the new disease.

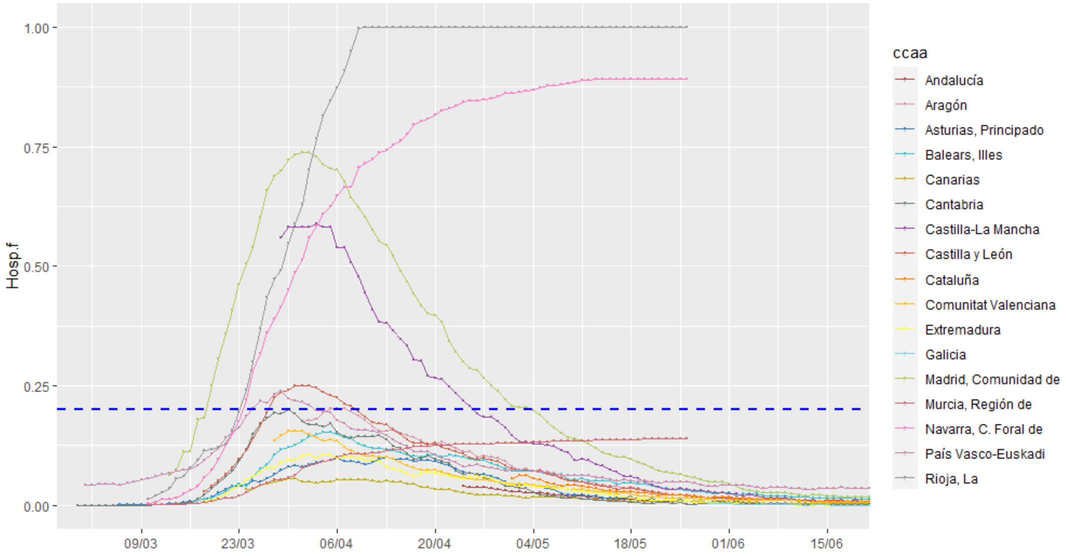
In addition, Figure 6 shows the occupancy of hospital beds in the same period, taking as thresholds the availability of public and private hospital beds for each region. Dashed horizontal blue line represents the average number of hospital beds available in pre-pandemic periods. With respect to this indicator, the situation was not as stressed as in the case of the previous one. It is important to note that the behavior is uneven between the two indicators. The methodology reported in this paper takes into account the worst scenario of the two indicators.

Figure 5. Occupation ICU Hospitalization between February 2th and June 21th.



Source: Casal (2020) and own elaboration

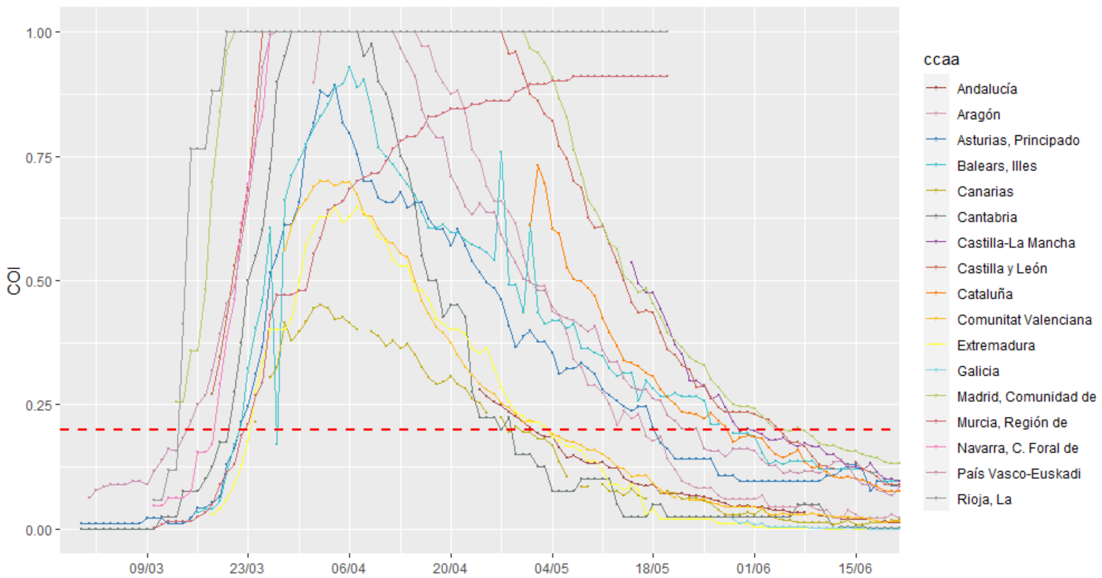
Figure 6. Occupation Hospitalization between February 2th and June 21th.



Source: Casal (2020) and own elaboration

Figure 7 shows the evolution of the COI indicator between 2 February and 21 June. As the indicator selects on each day t the maximum of the two indicators, the curves show a behavior similar to that of Figure 5. In this period, the growth of hospitalizations was exponential and the saturation of the health systems was very fast, in particular of the ICUs. Health systems showed flexibility by increasing the supply of inpatient beds. However, it is much more costly and complex to increase the supply of ICU beds, because of the need for prepared infrastructures, technological devices and specialized human capital.

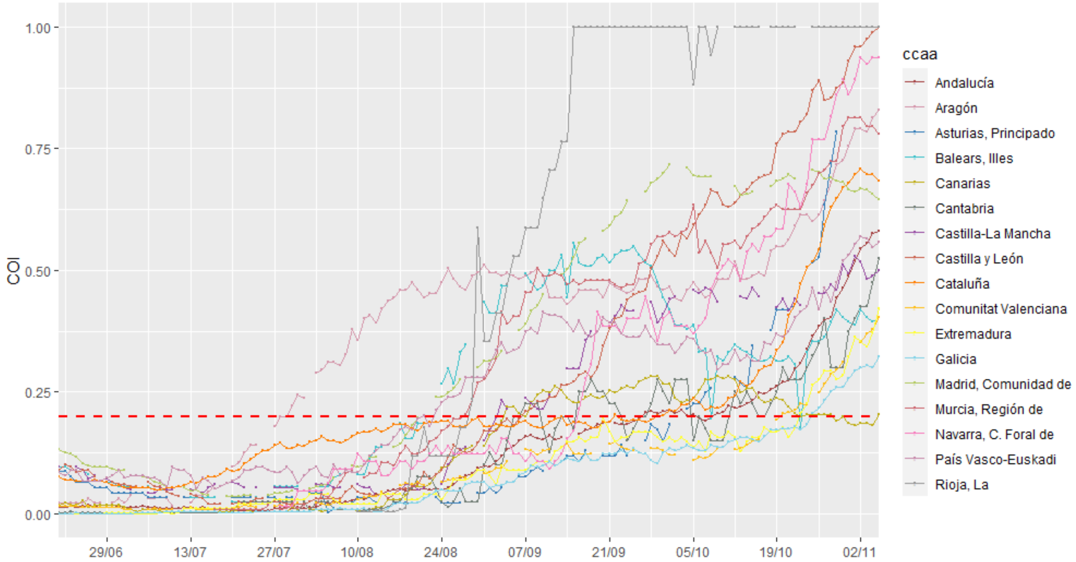
Figure 7. COI indicator between February 2th and June 21th.



Source: Casal (2020) and own elaboration

Finally, Figure 8 shows the COI indicator over a period from July to November 2020. In early July, the incidence rate was at its lowest since the beginning of the pandemic, showing an increase that culminated with the second wave of the pandemic. This period shows a more sustained increase over time, although it is noted that, with some exceptions, the thresholds above which it is necessary to suspend non-COVID-19 activity began to be reached at the end of August. However, according to other criteria, no measures were taken to mitigate the increase more rapidly.

Figure 8. COI indicator between June 29th and November 2th.



Source: Casal (2020) and own elaboration

Decision-making based solely on incidence rate is extremely risky for all the reasons outlined in this paper. The data provided by the hospitals are more realistic and therefore allow for a more efficient assessment of the situation.

4. Conclusions

Although the situations in hospitals were resolved in all cases by adding new beds to the services to care for COVID patients, the statistics that were---and still are---shown to report the epidemic data are not giving accurate information. In short, we can say that they reflect the efforts of health systems not to leave people with COVID without a hospital bed. But---and this is our main point---, they do not give the necessary information on the extent to which hospitals are providing a complete, competent and optimal service to the general health of the population. This is exactly the contribution that the proposed new indices are intended to make.

Most public health agencies in regions or countries report the SARS-COV2 disease situation on a daily basis based on cases confirmed by various diagnostic tests. Epidemiological curves based on confirmed cases are used as a key indicator for health decision-making. However, cumulative incidence often provides a distorted view of contagion. The number of diagnoses made for the detection of the test can significantly alter the CI. The different types of tests performed have associated types of errors known as false positives and false negatives. In large sample sizes and depending on the magnitude of the error, these can lead to significant variations.

Although there are significant divergences in hospital bed and ICU ratios between Spanish regions, the different health systems do not differ in terms of care and quality of service. In this paper, we provide an indicator that does not take into account the incidence rate for the reasons given above. Instead, we choose more realistic data such as hospital occupancy and ICU occupancy. This occupancy refers to the maximum occupancy of a region before the pandemic, without taking into account the possible extensions of services that hospitals have undergone in order to cope with the extraordinary demand caused by COVID-19. The composite indicator calculated as the maximum occupancy of hospital beds or ICU beds compared to the maximum before the start of the pandemic provides more realistic information on the impact of SARS-COV2 disease on regional health systems. The average occupancy of hospitals under normal conditions should be used as a reference to generate alerts when an epidemic compromises these thresholds.

The proposed index could be supplemented with new indicators. The onset of disease caused by COVID-19 has led to an increase in the demand for hospital resources such as ventilators and measuring devices. The unavailability of these supports generates a limitation similar to the one studied in this work. The Ministry of Health, Consumption and Social Welfare does not provide information in this direction. The inclusion of such an indicator would enrich the information provided by the composite indicator.

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Transparency statement

The senior author (guarantor responsible for the manuscript) affirms that this manuscript is an honest, accurate, and transparent report of the study submitted to of the study submitted to Studies of Applied Economy

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