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Original article

Epidemiology of the COVID-19 pneumonia in a group of hospitals from Madrid-Spain during the full period of the State of Alarm– HM cohort

Epidemiología de la neumonía por COVID-19 en un grupo de hospitales españoles durante todo el Estado de Alarma - Cohorte de hospitales HM

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Abstract

Introduction: To describe the epidemiology pattern of the COVID-19 pandemic during all Spanish State of Alarm.

Methods: Retrospective, observational, cohort and multicenter study. Inclusion criteria: age ≥18 years old, admitted for COVID-19 pneumonia in any of the centers of the HM Hospitals Group. Exclusion criteria: voluntary discharge, death in the emergency department, transfer to centers outside the HM group or incomplete data. State of Alarm period: 31/01/2020 to 05/07/2023. Predominant COVID-19 variant was defined when it exceeded 50% of the total isolates.

Results: During the study period, 2,992 patients were admitted due to a COVID-19 pneumonia, 295 patients (9.86%) non-survive. Survivors and non-survivors were different in age and comorbidities. However, both cohorts presented a similar net of interaction between comorbidities. Hospital admissions per week showed an evolution in "peaks" with "troughs". A total of 197 (6.48%) patients were admitted to the ICU, of whom 52 (26.39%) non-survive; this subgroup stood out for having a higher proportion of septic shock, orotracheal intubation and acute renal failure, as well as a lower proportion of pulmonary thromboembolism and delirium. Concerning the viral variants, the incidence for the original variant was 4.05 cases/day, for the alpha variant 3.82 cases/day, for the delta variant 1.16 cases/day and for the omicron variant 1.35 cases/day.

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Conclusion. Almost 1 of 10 patients with COVID-19 pneumonia death, a proportion that increased to 1 of 4 in case of being admitted to the ICU. Unexpectedly, interaction between comorbidities did not differ between survivors and non-survivor's patients. Predominant variants were associated with different hospital admission rates but not influence the presence of peak-troughs evolution of the pandemic.

Keywords: COVID-19. Pneumonia. Pandemia. SARS-CoV-2. Health crisis. Epidemiology. VOCs variants.

Resumen

Introducción: Describir el patrón epidemiológico de la pandemia de COVID-19 durante todo el estado de alarma en España.

Métodos: Estudio retrospectivo, observacional, de cohorte y multicéntrico. Criterios de inclusión: edad ≥18 años, ingreso por neumonía COVID-19 en cualquiera de los centros del Grupo de Hospitales HM. Criterios de exclusión: alta voluntaria, fallecimiento en el servicio de urgencias, traslado a centros fuera del grupo HM o datos incompletos. Estado de alarma: del 31/01/2020 al 05/07/2023. Se definió como variante predominante de COVID-19 aquella que superó el 50% de los aislamientos totales.

Resultados: Durante el período de estudio, se admitieron 2.992 pacientes por neumonía COVID-19, de los cuales 295 pacientes (9,86%) no sobrevivieron. Los sobrevivientes y no sobrevivientes mostraron diferencias en edad y comorbilidades. Sin embargo, ambas cohortes presentaron una red de interacción similar entre las comorbilidades. Los ingresos hospitalarios por semana mostraron una evolución en "picos" y "valles". Un total de 197 pacientes (6,48%) fueron admitidos en la UCI, de los cuales 52 (26,39%) no sobrevivieron; este subgrupo se caracterizó por una mayor proporción de shock séptico, intubación orotraqueal e insuficiencia renal aguda, así como una menor proporción de tromboembolismo pulmonar y delirio. En relación con las variantes virales, la incidencia fue de 4,05 casos/día para la variante original, 3,82 casos/día para la variante alfa, 1,16 casos/día para la variante delta y 1,35 casos/día para la variante ómicron.

Conclusiones: Casi 1 de cada 10 pacientes con neumonía por COVID-19 falleció, proporción que aumentó a 1 de cada 4 en caso de ingreso en la UCI. De manera inesperada, la interacción entre comorbilidades no difería entre pacientes sobrevivientes y no sobrevivientes. Las variantes predominantes se asociaron a diferentes tasas de ingreso hospitalario, pero no influyeron en la evolución de picos y valles de la pandemia.

Palabras clave: COVID-19. Neumonía. Pandemia. SARS-CoV-2. Crisis sanitaria. Epidemiología. Variantes VOC.

Introduction

The COVID-19 pandemic, caused by the SARS-CoV-2 virus, unleashed an unprecedented global health crisis since its emergence in late 2019 [1]. Spain was one of the most affected countries in Europe, with official data from the Ministry of Health estimating beyond 13 million infections and 130,000 deaths [2,3]. The emergence of this new virus also caused a significant financial stress to the healthcare system. For example, Drago et al. [3] estimated that the cost of care for each COVID-19 patient was €1,000 per day, a cost that trebles in the case of intensive care unit [4] admissions. From a virological perspective, SARS-CoV-2 continuously mutated over time, giving rise to new variants. Some of these were classified as variants of concern (VOCs) by the World Health Organization (WHO) due to their association with increased transmissibility, heightened disease severity, reduced immune response, or diminished efficacy of therapeutic interventions [5].

In Spain, several studies have analyzed the epidemiology of SARS-CoV-2-associated pneumonia [6-8]. However, to our knowledge, none of them have covered the entire health crisis defined by the Spanish Government as the "State of Alarm". The aim of this study was to provide a comprehensive analysis of the epidemiological characteristics of patients with COVID-19 pneumonia admitted to HM Hospitals Group in Madrid (Spain) during the entire State of Alarm. Likewise, to analyze the effect of the predominant SARS-CoV-2 variant in the epidemiological patterns. Some data from the first wave (1 March to 5 April 2020) of the pandemic has been previously published [7].

Material and methods

This is a retrospective, observational, multicenter cohort study. Inclusion criteria: adult patients (≥ 18 years of age), hospitalized with a COVID-19 pneumonia in centers belong to HM Hospitals in Madrid, Spain (HM Sanchinarro University Hospital, HM Puerta del Sur University Hospital, HM Madrid University Hospital, HM Monteprincipe University Hospital and HM Torrelodones University Hospital). In the case of more than one hospital admission, only the first one was considered. COVID-19 pneumonia was defined by the presence of typical characteristics on the chest radiography or CT (e.g. ground glass opacities, bilateral infiltrates, etc.) [9] associated with a positive nasal or throat SARS-CoV-2 swab test (antigen or PCR) within 7 days of admission. Exclusion criteria: voluntary discharge, death in the emergency department,

transfer to centers outside of HM Hospitales group or incomplete data in the medical record.

The study period was compiled between 31/01/2020 to 05/07/2023 (date of the first case of COVID-19 diagnosed in Spain to the date of the official end of the State of Alarm in Spain, respectively).

Participants were retrieved automatically from the electronic patient record systems. Clinical data was extracted at hospital discharge by the staff of the documentation and archiving department. Data collected were: age, sex, date of hospital admission and discharge, comorbidities (diabetes, smoking, alcoholism, dyslipidemia, hyperuricemia, chronic arterial hypertension [CAH], chronic heart failure [CHF], ischemic coronary heart disease, chronic obstructive pulmonary disease [COPD], asthma, chronic liver disease, chronic renal failure [CRF], stroke and thyroid disease), date of admission and discharge from the ICU, ICU events (need for orotracheal intubation [OTI], tracheostomy, renal replacement therapy [RRT], septic shock, adult respiratory distress syndrome [ARDS], pulmonary thromboembolism [PTE], cardio-respiratory arrest [CRA], delirium) and discharge outcome. The predominant SARS-CoV-2 variant was defined as the one that exceeded 50% of all isolates. Based on official data from the Spanish Ministry of Health, the following periods can be recognized [5]: (a) original variant (v_orig) from the start of the pandemic to 31/01/2021 (366 days); (b) alpha variant (v_alpha) from 01/02/21 to 20/06/2021 (140 days), (c) delta variant (v_delta) from 21/06/2021 to 12/12/2021 (175 days) and (d) omicron variant (v omicron) from 13/12/2021 to 05/07/ 2023 (572 days).

Statistical analysis. Categorical variables were presented as number of cases and percentages, continuous variables as median and interquartile range. Categorical variables were compared using the chi-square or Fisher's exact test, and continuous variables were compared using the non-parametric Mann-Whitney U or Kruskall-Wallis test as appropriate. The group of living patients was compared with those who died at hospital discharge.

Comorbidities data was visualized through a heatmap and network graphs. Network graphs were created using the graph function, employing the kk algorithm for node layout design. For each network, the width of the edges was visualized according to the weight of the interaction and the size of the nodes was adjusted based on the percentage measure attribute. Additionally, specific structural features derived from the networks were determined, and permutation tests were conducted to assess differences between the networks of survivor and non-survivor patient groups. The evaluated structural features included strength (defined as the sum of the weights of a nodes´ connections in the network), betweenness centrality (the frequency with which a node acts as an intermediary on the shortest paths between other nodes), clustering coefficient (the degree of clustering of a node, indicating how connected its neighbors are to each other), average shortest path length (the average shortest path length between all pairs of nodes in the network), and network quality (the measure which evaluates the quality of the division into communities). Permutation tests were performed with 1,000 interactions.

A value of P <0.05 was considered significant. All analyses were performed using the R statistical program and its libraries [10]. The manuscript was written in accordance with the recommendations of the STROBE guidelines for the publication of observational cohort studies [11].

Ethics. The ethics committee approved the study and provided the informed consent for the waiver.

Results

During the study period, 8,102 patients were diagnosed with the SARS-CoV-2 infection:559 (6.90%) were excluded due to missing data and 4,551 (56.17%) did not meet the inclusion criteria. The main demographic characteristics of the 2,992 (36.93%) COVID-19 patients with pneumonia included in this study can be appreciated in **table 1**.

Hospital admissions per week showed an oscillating evolution characterized by "peaks" separated by "troughs". The maximum "peak" was the first one that extended from week 9 to week 17 of 2020, reaching 218, 189 and 113 admissions during weeks 11, 12 and 13 respectively (**Figure 1**).

A total of 295 cases (9.86%) did not survive, being different from those that survive mainly in terms of age, day of hospitalization and comorbidities; other differences can be appreciated in **table 1**.

Regarding comorbidities, the medium number of comorbidities per patient was higher in non-survivor than survivor patients. Despite the network analysis demonstrating that diabetes, smoking, and arterial high blood pressure were the most connected (interrelated) comorbidities (**Figure 2**, **Table S1 - supplementary material**), both networks were similar: clustering coefficient (CC) for non-survivors was 0.000, and for survivors, 0.481 (p-value = 0.106); average shortest path length (ASPL) for non-survivors was 0.492, and for survivors, 1.436 (p-value = 0.397); and network modularity (Q) for survivors was 0.115, and for non-survivors, 0.306 (p-value = 0.288).

Table 1. Demographic aspects of the total number of patients according to their evolution at discharge from the hospital.

	All patients (n=2,992)	Survivors (n=2,697)	Non-survivors (n=295)	p value
Characteristic				
Age (years)*	69.00 [56.00-80.00]	67.00 [55.00-78.00]	83.00 [74.00-89.00]	<0.001
Sex – Female**	1289 (43.08%)	1159 (42.97%)	130 (44.07%)	0.765
Days of hospitalisation on the ward*	7.00 [4.00-11.00]	7.00 [4.00-11.00]	9.00 [5.00-17.00]	<0.001
ICU admissions**	197 (6.58%)	145 (5.38%)	52 (17.63%)	<0.001
Comorbidities				
Comorbidity per patient**	1.00 [0,00-2.00]	1.00 [0,00-2.00]	2.00 [1,00-3.00]	<0.001
Diabetes**	503 (16.8)	437 (16.20)	66 (22.37)	0.009
Smoker**	141 (4.71)	133 (4.93)	8 (2.71)	0.118
Alcoholism**	52 (1.74)	45 (1.67)	7 (2.37)	0.519
Dyslipidaemia**	781 (26.10)	674 (24.99)	107 (36.27)	<0.001
Hyperuricaemia**	165 (5.51)	143 (5.30)	22 (7.46)	0.160
Chronic arterial hypertension**	1362 (45.52)	1180 (43.75)	182 (61.69)	<0.001
Chronic heart failure**	146 (4.88)	123 (4.56)	23 (7.8)	0.021
Ischaemic coronary heart disease**	208 (6.95)	168 (6.73)	40 (13.56)	<0001
COPD**	260 (8.69)	223 (8.27)	37 (12.54)	0.018
Asthma**	185 (6.18)	170 (6.30)	15 (5.08)	0.485
Chronic liver disease**	120 (4.01)	101 (3.74)	19 (6.44)	0.037
Chronic renal failure**	174 (5.82)	145 (5.38)	29 (9.83)	0.003
Stroke**	97 (3.24)	79 (2.93)	18 (6.10)	0.006
Thyroid disease**	283 (9.46)	254 (9.42)	29 (9.83)	0.900

*median [percentile 25- percentile 75]. **absolute frequency (percentage).
COPD: chronic obstructive pulmonary disease.

Of the 197 (6.48%) patients admitted to the ICU, 52 (26.39%) did not survive; this subgroup was notable for having a higher proportion of septic shock, OTI and acute renal failure, as well as a lower proportion of PTE and delirium (**Table 2)**.

Regarding the SARS_CoV-2 variants, the incidence of pneumonia for v_orig was 4.05 cases/day, for v_alpha 3.82 cases/day, for v_delta 1.16 cases/day and for v_omicron 1.35 cases/day. It´s noteworthy that as one variant was replaced by another, hospital days and mortality decreased. Other characteristics between different variants can be appreciated in **table 3**.

Discussion

The present study, to our knowledge, is the first that includes all consecutive hospitalized patients with COVID-19 pneumonia during the entire period of the State of Alarm in Spain, highlighting the impact of the disease in our community. Specifically, almost 1 in 10 patients died, a proportion that increased to 1 in 4 cases where ICU admission was required.

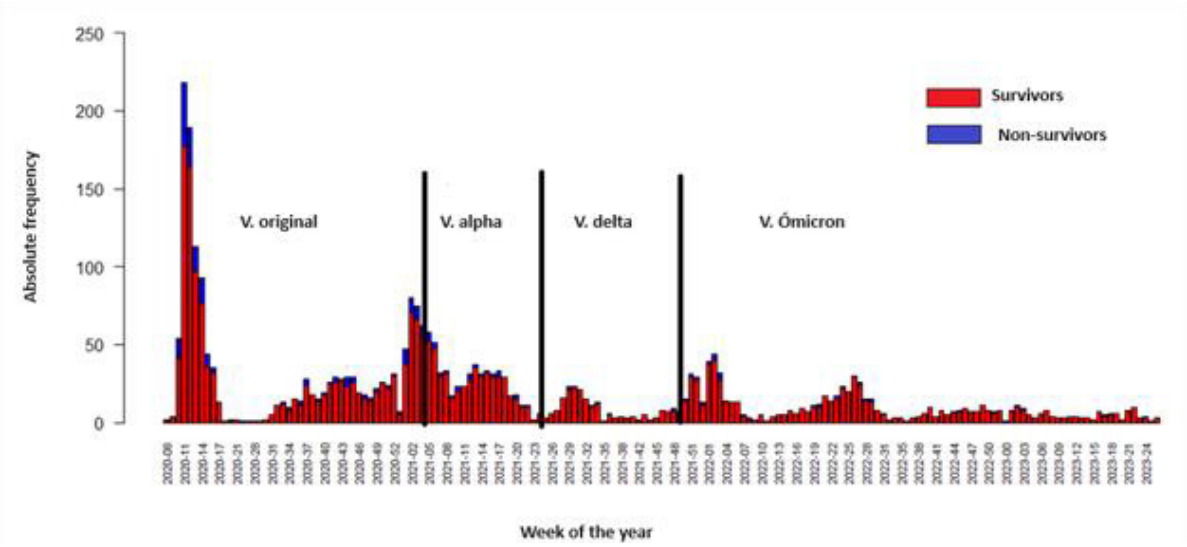

Figure 1. Evolution of COVID-19 pneumonia admissions aggregated between survivors and non-survivors at hospital discharge.

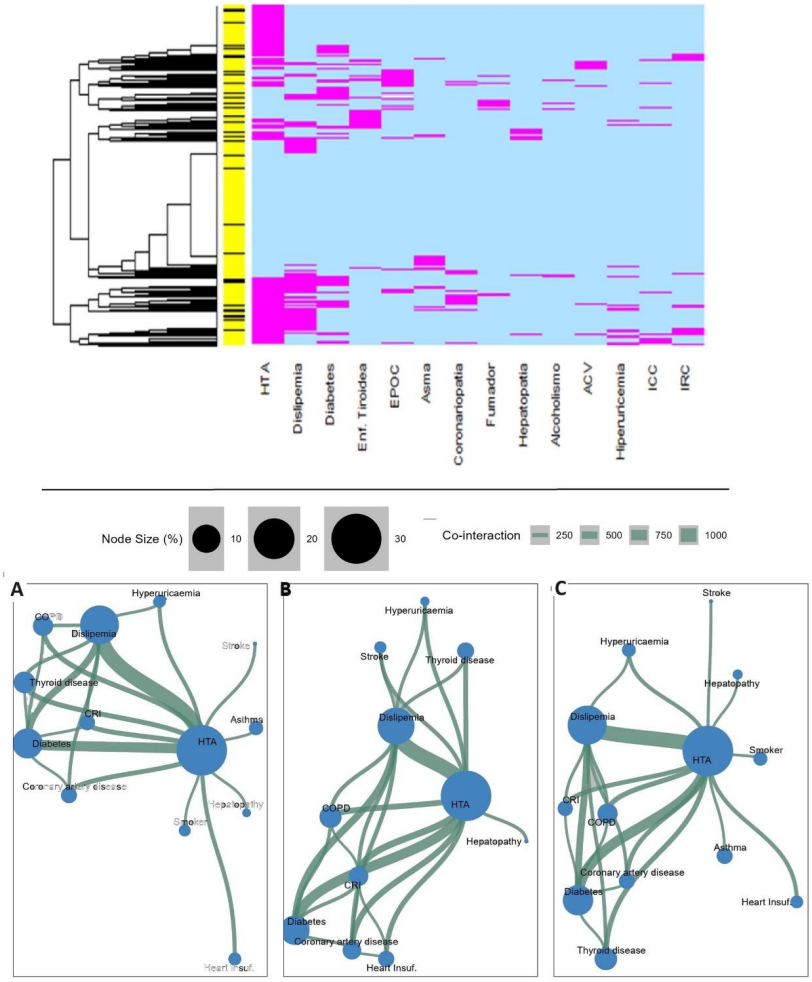

Figure 2. Comorbidities.

Upper panel (right to left): dendogram (each row represents a patient); vertical column: yellow lines: survivors; black lines: non-survivors; main square: pink lines: presence of the comorbidity, skyline: absence of the comorbidity.

Lower panel: A: all patients, B survivors and C non-survivors.

HTA: high blood pressure; COPD: chronic obstructive pulmonary disease; ACV: cerebral stroke; ICC: chronic heart failure; IRC: chronic renal insufficiency.

Table 2. Demographics of patients admitted to the ICU according to their evolution at discharge from hospital.

Characteristics	All ICU patients (n=197)	Survivors (n=145)	Non-survivors (n=52)	p value
Age (years)*	65.00 [59.00 - 74.00]	64.00 [58.00 - 73.00]	69.00 [62.00-75.27]	0.001
Sex – Female**	62 (31.5%)	49 (33.8%)	13 (25.0%)	0.319
Days of stay in ICU*	5.42 [1.14 - 10.67]	4.68[1.05 - 9.72]	6.64 [1.88 - 15.11]	0.204
Complications				
Septic shock**	18 (9.14)	3 (2.07)	15 (28.85)	<0.001
ARDS**	83 (42.13)	56 (38.62)	27 (51.92)	0.133
Orotracheal intubation**	104 (52.79)	68 (46.90)	36 (69.23)	<0.001
Tracheostomy**	40 (20.30)	26 (17.93)	14 (26.92)	0.237
Acute renal failure**	50 (25.38)	19 (13.10)	31 (59.62)	<0.001
Renal replacement therapy**	7 (3.55)	2 (1.38)	5 (9.62)	0.015
PTE**	36 (18.27)	32 (22.07)	4 (7.69)	0.036
Cardiorespiratory arrest**	3 (1.52)	1 (0.69)	2 (3.85)	0.171
Delirium**	21 (10.66)	19 (13.10)	2 (3.85)	0.111

*median [percentile 25- percentile 75]. **absolute frequency (percentage).
ARDS: síndrome de distrés respiratorio agudo, PTE: pulmonary trhomboembolism.

The time evolution showed a saw-teeth pattern, with peaks not fully associated with the change in the predominant virus variant. Comorbidities conditions were extremely common; however, their relations did not differ between survivors and non-survivors.

In terms of mortality, an international meta-analysis, which included 423,117 patients from 42 studies published before August 2020 (13 in China, 11 in the USA, 3 in Italy, 2 in Turkey, 2 in Spain, 2 in Mexico, 2 in Korea, 1 in France, 1 in Australia, 1 in Asia, 1 in Brazil, 1 in the UK and 2 in other regions), reported a meta-mortality of 17.62% [12]. In Spain, Garcia-Carretero et al. [6] in a study that included almost half a million patients hospitalized for COVID-19 during the years 2020-2021 reported a mortality of 14.3%. In another study by the same author that, including 3,315 patients admitted to a single public hospital in Madrid during the period of 25/02/2020 to 12/05/2020 (corresponding to the so-called "first wave"), found a mortality of 9.4% [13]. Additionally, Jiménez E *et al*. [14] in a study including 1,393 patients admitted to a single public hospital in Madrid during the period 01/03/2020 to 28/05/2020, reported a mortality of 21.2%. The overall mortality in our study was 9.86% (26.39% when intensive care was required) with a downward trend over time (at the beginning of the pandemic, corresponding to the original variant, there was a maximum of 13.48% which progressively decreased to reach a minimum of 5.84% with the last variant identified). Our results rank among the best reported, which may be attributed to the early establishment of an institutional monitoring committee by HM Hospitals, in addition to local committees at each hospital. This structure facilitated coordination among key departments involved in patient care, ensuring standardized protocols for treatment incorporation and prescription, hospital and ICU admission criteria, discharge processes, and other critical aspects of COVID-19 management.

The pandemic "peaks and troughs" evolution has been well demonstrated by several authors [15]; our results agree with them. However, not all peaks were similar. For example, the first two peaks (start of the pandemic and early 2021) being recognized as the main ones in terms of the magnitude of admissions. Nevertheless, these peaks were distinguished by their onset; the first being "explosive" and the second showed a slow increase. Meanwhile, after August 2022 (week 31), an evolutionary change can be seen, acquiring a "flattened plateau" shape in which a similar number of patients were always maintained with minimal variations. It is striking that these peaks/troughs corresponded to changes in the season

Table 3. Demographics of inpatients by predominant variant.

Characteristic	All patients (n=2,992)	Original variant (n=1,484)	Alpha variant (n=535)	Delta variant (n=203)	Omicron variant (n=770)	P valor
Age (year)*	69.00 [56.00-80.00]	67.00 [56.00-78.00]	62.00 [52.00-74.00]	58.00 [43.00-71.50]	78.00 [66.00-86.00]	<0.001
Sex – Female**	1289 (43.08%)	605 (40.77%)	220 (41.12%)	78 (38.42%)	386 (50.13%)	<0.001
Days of hospitalization on the ward*	7.00 [5.00-12.00]	8.00 [5.00-12.00]	8.00 [5.00-12.00]	6.00 [2.00-9.25]	6.00 [4.00-9.00]	<0.001
ICU admissions**	197 (6.58%)	120 (8.09%)	47 (8.79%)	12 (5.91%)	18 (2.34%)	<0.001
Exitus**	295 (9.86%)	200 (13.48%)	39 (7.29%)	11 (5.42%)	45 (5.84%)	<0.001
Comorbidities						
Comorbidities per patient*	1.00 [0.00-2.00]	1.00 [0.00-2.00]	1.00 [0.00-2.00]	1.00 [0.00-2.00]	2.00 [1,00-3.00]	<0.001
Diabetes**	503 (16.81)	254 (17.12)	74 (13.83)	24 (11.82)	151 (19.61)	0.010
Smoker**	141 (4.71)	49 (3.30)	28 (5.23)	16 (7.88)	48 (6.23)	0.001
Alcoholism**	52 (1.74)	22 (1.48)	8 (1.50)	4 (1.97)	18 (2.34)	0.464
Dyslipaemia**	781 (26.10)	414 (27.90)	121 (22.62)	38 (18.72)	208 (27.01)	0.008
Hyperuricaemia**	0.06 (0.23)	0.05 (0.22)	0.04 (0.21)	0.06 (0.25)	0.07 (0.25)	0.190
Chronic arterial hypertension arterial**	1362 (45.52)	674 (45.42)	225 (42.06)	61 (30.05)	402 (52.21)	<0.001
Chronic heart failure**	146 (4.88)	49 (3.30)	13 (2.43)	5 (2.46)	79 (10.26)	<0.001
Ischaemic coronary heart disease**	208 (6.95)	109 (7.35)	16 (2.99)	8 (3.94)	75 (9.74)	<0.001
COPD**	260 (8.69)	79 (5.32)	39 (7.29)	21 (10.34)	121 (15.71)	<0.001
Asthma**	185 (6.18)	103 (6.94)	33 (6.17)	14 (6.90)	35 (4.55)	0.157
Chronic liver disease**	120 (4.01)	60 (4.04)	24 (4.49)	7 (3.45)	29 (3.77)	0.896
Chronic renal failure**	174 (5.82)	66 (4.45)	18 (3.36)	4 (1.97)	86 (11.17)	<0.001
Stroke**	97 (3.24)	41 (2.76)	10 (1.87)	4 (1.97)	42 (5.45)	0.001
Thyroid disease**	283 (9.46)	115 (7.75)	55 (10.28)	8 (3.94)	105 (13.64)	<0.001

*median [percentile 25- percentile 75]. **absolute frequency (percentage).
COPD: chronic obstructive pulmonary disease.

of the year, implying changes in the behavior of society, rather than the emergence of a new variant. In fact, our results suggest that each variant may have characteristics, highlighting the trend towards lower severity (lower mortality, ICU admissions and days of hospitalization) and the involvement of patients with advanced age and greater comorbidities. While this finding is difficult to interpret, we speculate that it may be linked to improved immune system response due to infection or vaccine intervention [16], the availability of targeted antivirals [17,18] and immunomodulatory therapies [19,20], optimization in the implementation of supportive measures and change in variant virulence [21,22].

Genetic variants of SARS-CoV-2 have been globally surging in many countries around the world. However, the pandemic has changed since the irruption of the Omicron variant [23]. Several studies have suggested that the Omicron variant is associated to an increase in the transmissibility but a significantly lower disease severity than the Delta variant (hospitalization, oxygen requirements, mechanical ventilation, and death); however, studies against other VOCs are scarce [24,25] In our study, during the period of omicron variant predominance, the number of hospital and ICU admissions decreased and the median age of each patient and number of comorbidities increased. Although this finding must be interpreted cautiously, this suggests that younger patients with no, or few, comorbidities, usually did not require hospitalization during the Omicron predominance.

The analysis of comorbidities is important mainly because it allows the identification of individuals at higher risk of a worse prognosis and therefore to be prioritized for certain intervention, and for the understanding of the pathophysiological mechanisms underlying the infection [26]. Our study strongly suggested that non-survivor's patients had more comorbidities than those who survived, whether related to the respiratory system (COPD and asthma), cardiovascular (dyslipemia, CAH, chronic heart failure and ischemic coronary heart disease), diabetes, CRF and stroke). It is striking that smoking was under-represented in the group of non-survivors, which could be linked to a selection bias given that the proportion of COPD patients is increased in this group [27].

In addition to assessing the effect of each comorbidity in an isolated form, it is possible to analyze their global interconnections in a net [28]. Unexpectedly, we did not find any difference between survivors and non-survivors' networks graph; we speculate that this finding may be explained because both nets shared the same physiopathology mechanism (e.g., inflammation, immune response, or genetic predisposition) that create common pathways that contribute to the co-occurrence of the disease but not influence their outcome. In addition, network graphs may reveal general principles of disease interactions, and main chronic conditions like diabetes or hypertension may act as hubs that connect other comorbidities that do not influence the mortality.

Slightly more than a quarter of the patients required intensive care, with a mortality rate of 26.3%, especially in men aged around 65 years; all of which coincides with data published nationally and internationally [29-31]. Among the main complications was ARDS, present in 1 out of 2 patients admitted to the ICU and in which, strikingly, it was not associated with increased mortality. This unexpected finding could be explained, among other reasons, by the clinical inability to distinguish between bilateral pneumonia and ARDS [32]. PTE and delirium were frequent complications that predominated in the group that survived. We speculate that both findings could be explained by a selection bias, given that the most severe patients who proportionally died more often could not be transferred for a CT angiography or could not be awakened for delirium assessment [33]. Regarding the days of stay in the ICU, although the median stay was almost 6 days, 25% of admissions stayed more than 10 days.

This study has some limitations. First, the stratification of the cohort based on predominant SARS-CoV-2 variants was derived from ecological rather than individual data, which may have led to some misclassification. However, we consider this margin of error to be minimal, as official data from the Spanish Ministry of Health [5] indicate that transition periods between variants were short, with each new predominant variant rapidly displacing the previous one. Second, follow-up was limited to hospital discharge, preventing the assessment of important post-discharge events such as readmission or post-COVID syndrome. Lastly, the impact of COVID-19 vaccination on clinical outcomes could not be analyzed.

Despite these limitations, this study also presents notable strengths. Most importantly, the rigorous data collection and retrieval process, facilitated by a unified electronic medical record system across all HM Hospitals, ensured comprehensive identification of COVID-19 admissions from the onset of the pandemic, minimizing potential biases inherent in retrospective studies. Additionally, the homogeneity of the enrolled patients and the robust diagnostic criteria for COVID-19 pneumonia significantly enhance the study's external validity. Another key strength is its multicenter design, involving five hospitals across different geographic areas of Madrid, which supports the generalizability of the findings. Lastly, the inclusion of the entire period under the State of Alarm provides a comprehensive and longitudinal perspective on the impact of COVID-19 in this setting.

In summary, this study, which to our knowledge is the first to include the entire period of the State of Alarm, describes the epidemic progression of COVID-19 pneumonia in a group of private hospitals in Madrid-Spain. It shows that 9 out of 10 hospitalized patients with COVID-19 were cured, placing Madrid's healthcare system in a privileged position worldwide in terms of healthcare outcomes.

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Conflict of interest

The authors declare that they have no conflicts of interest.

Author contributions

Conceptualization, J.B., M.R., J.V. and P.C-F.; methodology, J.B., M.R., J.V. and P.C-F.; investigation, J.B., M.R., J.V., P.V., M.V., S.O, A. T-G, J.M., L.T-H., C.A., L.A., L.M., S.M., A.P., M. S-C., J.E.G., J.P. and P.C-F.; writing—review and editing, J.B., M.R., J.V., P.V., M.V., S.O, A. T-G, J.M., L.T-H., C.A., L.A., L.M., S.M., A.P., M. S-C., J.E.G., J.P. and P.C-F. All authors have read and agreed to the published version of the manuscript.

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Supplementary material / Material suplementario

Supplementary Table 1. Network measures between survivors and non-survivors at hospital discharge.

Comorbidity	Strength			Betweenness		
	non-survivors	survivors	p-value	non-survivors	survivors	p-value
Diabetes	0.00	3.03	0.011	0.00	2.00	0.557
Smoker	0.00	2.69	0.035	0.00	0.00	1.000
Alcoholism	0.00	3.55	0.584	0.00	16.00	0.626
Dislipemia	1.25	2.41	0.568	0.00	0.00	1.000
Hyperuricaemia	1.58	2.26	0.827	4.00	0.00	0.375
Artherial high blood pressure	1.16	7.09	0.014	0.00	40.00	0.184
Heart chronic failure	0.67	3.89	0.256	0.00	0.00	1.000
Thyroid disease	0.00	0.00	1.000	0.00	0.00	1.000
Coronary artery disease	0.00	3.40	0.107	0.00	0.00	1.000
COPD	0.00	3.82	0.127	0.00	44.00	0.343
Asthma	0.00	0.00	1.000	0.00	0.00	1.000
Hepatopathy	0.00	1.60	0.432	0.00	0.00	1.000
Chronic renal insufficiency	2.17	5.27	0.442	8.00	12.00	0.827
Stroke	0.00	0.91	0.377	0.00	0.00	1.000