



HAL
open science

Major interregional differences in France of COVID-19 hospitalization and mortality from January to June 2020

Joris Muller, Pierre Tran Ba Loc, Florence Binder Foucard, Aurélie Borde, Amélie Bruandet, Maggie Le Bourhis-Zaimi, Xavier Lenne, Éric Ouattara, Fabienne Séguret, Véronique Gilleron, et al.

► To cite this version:

Joris Muller, Pierre Tran Ba Loc, Florence Binder Foucard, Aurélie Borde, Amélie Bruandet, et al.. Major interregional differences in France of COVID-19 hospitalization and mortality from January to June 2020. *Epidemiology and Public Health = Revue d'Epidémiologie et de Santé Publique*, 2022, 70 (6), pp.265-276. 10.1016/j.respe.2022.08.008 . hal-03885736

HAL Id: hal-03885736

<https://hal.science/hal-03885736>

Submitted on 4 Sep 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Available online at
ScienceDirect
 www.sciencedirect.com

Elsevier Masson France
EM|consulte
 www.em-consulte.com



Article original

Major interregional differences in France of COVID-19 hospitalization and mortality from January to June 2020



Variabilité de l'incidence des hospitalisations et de la mortalité entre les régions lors de la première vague de COVID-19 entre janvier et juin 2020 en France

Joris Muller^{a,*}, Pierre Tran Ba Loc^a, Florence Binder Foucard^a, Aurélie Borde^b,
 Amélie Bruandet^c, Maggie Le Bourhis-Zaimi^d, Xavier Lenne^c, Éric Ouattara^b,
 Fabienne Séguret^e, Véronique Gilleron^b, Sophie Tezenas du Montcel^{f,g}

^a Service de Santé Publique, Hôpitaux universitaires de Strasbourg, 1 place de l'hôpital, BP426, 67091 Strasbourg Cedex, France

^b Service d'information médicale, CHU de Bordeaux, Le Tripode – Groupe Hospitalier Pellegrin, Place Amélie Raba-Léon, 33000 Bordeaux, France

^c Département d'information médicale, CHRU de Lille, 2 avenue Oscar Lambret, 59000 Lille, France

^d Département d'information médicale, Hospices Civils de Lyon, 3 Quai des Celestins, 69229 Lyon cedex 02, France

^e Unité d'évaluation et d'études épidémiologiques sur les bases Nationales d'Activité Hospitalière, Département d'information médicale, CHU de Montpellier, 191 av. du Doyen Giraud, 34295 Montpellier cedex 5, France

^f Institut Pierre Louis d'Epidémiologie et de Santé Publique, Sorbonne University, INSERM, N° BC 2908, 27 rue Chaligny, 75012 Paris, France

^g Assistance Publique – Hôpitaux de Paris, Pitié Salpêtrière – CHU Charles Foix, 7, avenue de la République, 94205 Ivry-sur-Seine, France

ARTICLE INFO

Article History:

Received 10 September 2021

Accepted 31 August 2022

Available online 13 September 2022

Keywords:

COVID-19

France

Cohort studies

Hospitals

Mortality

ABSTRACT

Introduction. – Even though France was severely hit by the COVID-19 pandemic, few studies have addressed the dynamics of the first wave on an exhaustive, nationwide basis. We aimed to describe the geographic and temporal distribution of COVID-19 hospitalisations and in-hospital mortality in France during the first epidemic wave, from January to June 2020.

Methods. – This retrospective cohort study used the French national database for all acute care hospital admissions (PMSI). Contiguous stays were assembled into “care sequences” for analysis so as to limit bias when estimating incidence and mortality. The incidence rate and its evolution, mortality and hospitalized case fatality rates (HCFR) were compared between geographic areas. Correlations between incidence, mortality, and HCFR were analyzed.

Results. – During the first epidemic wave, 98,366 COVID-19 patients were hospitalized (incidence rate of 146.7/100,000 inhabitants), of whom 18.8% died. The median age was 71 years, the male/female ratio was 1.16, and 26.2% of patients required critical care. The Paris area and the North-East region were the first and most severely hit areas. A rapid increase of incidence and mortality within 4 weeks was followed by a slow decrease over 10 weeks. HCFRs decreased during the study period, and correlated positively with incidence and mortality rates.

Discussion. – By detailing the geographical and temporal evolution of the COVID-19 epidemic in France, this study revealed major interregional differences, which were otherwise undetectable in global analyses. The precision afforded should help to understand the dynamics of future epidemic waves.

© 2022 Elsevier Masson SAS. All rights reserved.

R É S U M É

Introduction. – La France a été fortement touchée par la pandémie de COVID-19, et aucune étude n'a décrit de manière exhaustive son impact sur les hospitalisations. Notre objectif était de décrire la distribution

Abbreviations: SARS-CoV-2, Severe acute respiratory syndrome coronavirus 2; PMSI, Programme de médicalisation des systèmes d'information; SIR, Standardised incidence ratios; ATIH, Agence Technique de l'Information sur l'Hospitalisation; ICD, International Classification of Diseases; CCU, Critical care unit; CIR, Crude incidence rates of hospitalisation; CMR, Crude mortality rates; SMR, Standardised mortality ratios; HCFR, Hospitalised case fatality rate; INSEE, Institut national de la statistique et des études économiques

* Corresponding author.

E-mail address: joris.muller@jom.link (J. Muller).

<https://doi.org/10.1016/j.respe.2022.08.008>

0398-7620/© 2022 Elsevier Masson SAS. All rights reserved.

géographique et l'évolution temporelle des hospitalisations liées à la COVID-19 et la mortalité intra-hospitalière en France durant la première vague, de janvier à juin 2020.

Méthodes. – Cette étude de cohorte rétrospective est basée sur les données de la base nationale du PMSI. Les hospitalisations contiguës ont été rassemblées en « séquences de soins » afin de limiter les biais lors des calculs d'incidence et de mortalité. Les taux d'incidence et leur évolution, la mortalité et le taux de létalité ont été comparés selon différents niveaux géographiques. Les corrélations entre incidence, mortalité et taux de létalité ont été analysées.

Résultats. – Durant la première vague épidémique, nous avons dénombré 98 366 patients hospitalisés en France (taux d'incidence 146,7/100 000 habitants), parmi lesquels 18,8 % sont décédés. L'âge médian était de 71 ans, le ratio homme/femme de 1,16 et 26,2 % des patients ont nécessité des soins intensifs. L'Île-de-France et le Grand Est ont été les régions touchées les plus précocement et les plus sévèrement. Une rapide augmentation de l'incidence et de la mortalité sur 4 semaines a été suivie par une lente diminution durant 10 semaines. Le taux de létalité a progressivement diminué durant cette période et était corrélé positivement avec l'incidence et la mortalité.

Discussions. – La description géographique et temporelle de cette première vague épidémique de COVID-19 en France montre d'importantes variations régionales et départementales, qu'une analyse globale n'aurait pas pu mettre en évidence. La précision apportée par ces analyses peut aider à mieux comprendre la dynamique de futures vagues épidémiques.

Mots-clés. – COVID-19 ; France ; étude de cohorte ; hôpital ; mortalité

© 2022 Elsevier Masson SAS. All rights reserved.

1. Introduction

On 7 January 2020 the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), responsible for the coronavirus disease 2019 (COVID-19), was isolated in China [1,2]. In February 2020, when the situation seemed to be under control in Wuhan, the epidemic rapidly disseminated worldwide. On January 24, the first three European cases were reported in France, though earlier circulation of the virus has since been evidenced [3–5]. By the end of February, two clusters had been identified ; the first in the Oise department, north of Paris, and the second in the Haute-Savoie department [6,7]. In early March, a new cluster was identified in the Haut-Rhin department, in north-eastern France [8]. Just after the WHO made the assessment that COVID-19 could be characterised as a pandemic, France entered into a strict lockdown, from 17 March to 10 May 2020 [9,10].

Nationwide analyses of the first-wave period have been carried out in several different countries, including England, Germany, and Brazil [11–13]. To date, however, the few studies focused on the impact of the first wave in France on a nationwide level have been based on limited data sources across restricted periods [14–16].

The aim of this study was to describe the geographic and temporal distribution of 1) the incidence of hospital admissions and 2) in-hospital mortality in a nationwide cohort of patients with a diagnosis of COVID-19, admitted to any public or private hospital in France over the period of time corresponding to the first pandemic wave : January to June 2020

2. Methods

2.1. Database

We performed a retrospective cohort analysis on data from the French “Programme de Médicalisation des Systèmes d'Information” (PMSI)[17]. The PMSI is a comprehensive nationwide database that gathers hospitalisation data transmitted monthly by all public and private hospitals in France. Diagnoses are coded using the International Classification of Diseases, 10th Revision (ICD-10). After pseudonymisation, the data are uploaded by each hospital on a secure national platform managed by the French National Agency for the Management of Hospitalisation Data (Agence Technique de l'Information sur l'Hospitalisation, ATIH), and are integrated into the PMSI national database.

We included data from all patients hospitalised in French hospitals with COVID-19 during the first epidemic wave (January 1–June 30, 2020). Patients without a precise residency zip code or those living in a foreign country were excluded from the computation of these rates

(n = 361, 0.4 %). Patients were followed up through death or discharge, up until September 30, 2020. Hospital stays for COVID-19 were identified by the following ICD-10 codes : U07.10, U07.11, U07.12, U07.14 and U07.15 (Table 1), according to the national guidelines [18]. Confirmed cases were defined as patients with ICD codes U07.10, U07.12 and U07.14. All contiguous hospital stays for the same patient were gathered together and considered as a unique “care sequence” as previously detailed in another paper [19]. Two hospital stays were considered as contiguous if the discharge date of the first stay and the admission date of the second stay were separated by one day or less. If a patient was transferred from one hospital to another on the same day or during the night between two days, it was considered as a single care sequence. Each care sequence started with a hospital stay with COVID as defined above, but subsequent contiguous hospital stays were included regardless of COVID status. Counting care sequences instead of hospital stays limits bias when estimating incidence and mortality. The care sequence starting date was that of the first stay, and the end date was the date of death or the date of discharge of the last stay. In case of multiple hospitalisations with more than one day between the two care sequences, only the first sequence per patient was considered. We excluded care sequences having lasted for only a single day, except in the case of death.

The variables extracted for each patient were age, gender, zip code of residence, dates of hospital admission and discharge, in-hospital death, hospital name, hospital identification number, hospital zip code and admission to a critical care unit (CCU). Date of in-hospital death

Table 1

Codification of the International Classification of the diseases (ICD), 10th revision, modified by the ATIH to identify the COVID cases in the PMSI database.

| ICD 10 Code | Label | Number of patients with this code* (n = 98,366) |
|-------------|---|---|
| U07.10 | COVID-19, respiratory form, confirmed case | 64,584 (65.7 %) |
| U07.11 | COVID-19, respiratory form, unconfirmed case | 23,356 (23.7 %) |
| U07.12 | COVID-19, without symptoms, confirmed case | 4480 (4.6 %) |
| U07.14 | COVID-19, other clinical form, confirmed case | 3893 (3.9 %) |
| U07.15 | COVID-19, other clinical form, unconfirmed case | 2053 (2.1 %) |

Confirmed cases (U07.10, U07.12, U07.14) are based on polymerase chain reaction test or serology ; unconfirmed cases (U07.11, U07.15) are based on clinical evidence associated with chest computed tomography.

* In case of more than one U07.X code for a patient, the prioritization order is : U07.10 > U07.14 > U07.12 > U07.11 > U07.15

was the date of discharge for hospital stays with discharge code equal to death. These CCUs included intensive care units, intermediate care units (“soins intensifs”), and step-down units (“unité de surveillance continue”).

2.2. Statistical analysis

Two outcomes were considered : Incidence of hospitalisation, and in-hospital mortality. For these two outcomes, we considered temporal and spatial evolution. The time interval used was the week, with Monday being considered as the first day. For spatial descriptions, the zip codes indicating patient municipality of residence were gathered together to provide information at the departmental and regional level.

For continuous variables, the median is described and the interquartile ranges are given [IQR]. Categorical variables are described as number of patients and percentages.

The crude incidence rates of hospitalisation (CIR) were calculated with, in the numerator, the number of patients hospitalised according to their departments of residency, and in the denominator, the number of people in the department. Similarly, the crude mortality rates (CMRs) were calculated using the number of departmental hospital deaths in the numerator. To calculate standardised incidence ratios (SIR) and standardised mortality ratios (SMR), direct standardisation was done, using the official 2020 estimates by age and sex of the populations of the 101 French departments, as published by the National Institute of Statistics and Economic Studies (INSEE) [20]. To compute the weekly incidence of hospitalisation, the starting day of each care sequence determined at which week it would be counted. Patients without a precise residency zip code or those based in a foreign country were excluded from the computation of these rates ($n = 361$, 0.4 %).

The hospitalised case fatality rate (HCFR) was defined as the number of in-hospital deaths among the discharged COVID-19 patients.

Most of the analyses were performed on the secure ATIH platform. Data extraction and preparation were carried out on 9 January 2021, with SAS Guide Enterprise version 82. Sensitive data analysis was performed with R software 3.5 on ATIH platform, whilst non-sensitive (aggregated) data were downloaded to be computed with R software 4.1, using external packages from the tidyverse collection [21,22].

This study was conducted in accordance with the French legislation concerning reuse of the PMSI database (MR-005 of the Commission nationale de l'informatique et des libertés, CNIL), with inscription on the Health Data Hub public register (N° F20201117130456). Since we used pseudonymised discharge data, patients were not solicited.

3. Results

3.1. Main characteristics

From January to June 2020, a total of 98,366 patients were hospitalised in French healthcare facilities with COVID-19. Among them, 25,765 patients (26.2 %) spent at least one day in a critical care unit. The median length of a care sequence was 9 days (IQR = [4;16]). Median age was 71 years (IQR = [56 ; 83], range = [0 ; 108]). Sex ratio was 1.16 males to one female. Males were younger than females, with median ages of 69 (IQR = [56 ; 80]) and 74 (IQR = [57 ; 86]) years old, respectively. Distribution by age and sex is presented in Fig. 1. The cases confirmed by RT-PCR ($n=72,957$, 74.2 %) and the unconfirmed cases ($n=25,409$, 25.8 %) had the same median age (71y, IQR= [57 ; 83] vs 71y, IQR= [55 ; 84]), a similar male/female ratio (1.19 vs 1.10) and a higher proportion of cases with at least one day in a CCU (28.0 % vs 21.1 %).

A majority of patients ($n = 82,764$; 84.1 %) had a single hospital stay, while 13.1 % had two consecutive stays, and 2.8 % had three or more consecutive stays. The 98,366 care sequences included a total of 117,291 hospital stays, representing a total of 1,288,688 in-hospital days (Table 2).

Among the 1289 French public and private acute healthcare facilities, 77 % ($n = 995$) provided care to at least one COVID-19 patient. Amongst them, six public hospitals took care of 20 % of all COVID-19 patients : Assistance Publique — Hôpitaux de Paris (12.9 %), Hospices Civils de Lyon (1.7 %), Groupe Hospitalier de la Région de Mulhouse et Sud Alsace (1.6 %), Hôpitaux Universitaires de Strasbourg (1.6 %), Grand Hôpital de l'Est Francilien (1.5 %), and Assistance Publique-Hôpitaux de Marseille (1.3 %).

3.2. Incidence of hospitalisation

In a French population of 67,063,703, the crude national incidence of hospitalisation with COVID-19 from January to June 2020 was 146.7/100,000. The incidence of cases confirmed by RT-PCR was 108.8/100,000. The number of COVID-19 hospitalisations exceeded the threshold of 1000 hospitalisations per week on March 2 and increased exponentially, reaching a peak of 22,026 admissions/week within 4 weeks (week of March 23, incidence ratio : 32.84/100,000 inhabitants) (Fig. 2A). The decrease phase of this first wave was slower, taking 10 weeks before returning to a level inferior to 1000 admissions (week of June 1).

The demographic characteristics of the patients without a precise residency zip code or living in a foreign country ($n = 361$, 0.4 %), who were excluded from the by-department computation of rates, were comparable to those of the 98,005 included patients. While they presented with lower mean age (64 vs 68 years), and a lower proportion of probable COVID cases (19.9 % vs 25.9 %) the sex ratio and the death rate were comparable (see Table, Appendix 1).

Incidence varied greatly across French regions and departments (Table 3). The highest crude incidence ratio (CIR) and standardized incidence ratio (SIR) were in the Île-de-France followed by the Grand Est regions. At a departmental level, the highest crude incidence was in the Haut-Rhin (440.4/100,000), but after age and gender standardisation, the highest incidence was in Seine-Saint-Denis (520.7/100,000).

Similar to crude incidence, standardised incidence varied greatly from one department to another and from one week to the next (Fig. 3). We considered two thresholds, 20/100,000 and 60/100,000 inhabitants hospitalised per week, to define two levels of in-hospital alert. The threshold of 20 hospitalisations per 100,000 inhabitants by week was first exceeded in the Haut-Rhin (week of March 2) and then in the Oise (week of March 9). Most of the other departments exceeded this threshold at a later date, during the weeks of March 16 (20 departments) or March 23 (18 departments). Fifty-seven out of the 101 French departments never reached this weekly incidence. As regards the 44 departments with a weekly hospitalisation rate over the threshold of 20/100,000, median duration of the wave was 3.5 weeks (IQR = [2 ; 5]), reaching a maximum of 11 weeks in the overseas department of Mayotte. One overseas department, Guyane (French Guyana), exceeded this threshold during the week of June 8, 3 months after the first department. Only ten departments recorded hospitalisation incidence over 60/100,000 by week, and all with the exception of Guyane were located in the Île-de-France and Grand Est regions.

The peak, defined as the highest weekly standardised incidence rate, was reached for the overwhelming majority of departments ($n = 93$) during the weeks of March 23 (76 departments) and March 30 (17 departments). The highest weekly incidence rates occurred in Seine-Saint-Denis (119/100,000) and Haut-Rhin (96/100,000).

3.3. In-hospital mortality

Among the 98,366 patients hospitalised, 18,447 (18.75 %) died in hospital before September 30, representing a mortality ratio of 27 in-hospital deaths/100,000 inhabitants. These deceased patients were older than the average hospitalised COVID-19 patients (median age of 82 years, IQR = [72 ; 88]), and a majority were male (sex ratio of 1.47 males to one female).

Table 2
Analysis of hospital stays by the region and department of the healthcare provider.

| | Hospital stays | Patients | Mean stay duration (days) | Total days of hospital care | % of national total | Critical care stays | Total days of critical care |
|--------------------------------|----------------|---------------|---------------------------|-----------------------------|---------------------|---------------------|-----------------------------|
| France | 117,291 | 98,366 | 10.99 | 1,288,688 | 100.00 | 29,522 | 365,258 |
| Île-de-France | 42,199 | 35,866 | 11.16 | 470,934 | 36.54 | 11,979 | 148,727 |
| 75 Paris | 10,639 | 9362 | 11.80 | 125,538 | 9.74 | 3184 | 42,996 |
| 77 Seine-et-Marne | 3674 | 3321 | 10.68 | 39,240 | 3.04 | 967 | 11,787 |
| 78 Yvelines | 3517 | 3052 | 11.14 | 39,183 | 3.04 | 1061 | 12,094 |
| 91 Essonne | 3444 | 3120 | 12.24 | 42,138 | 3.27 | 946 | 12,594 |
| 92 Hauts-de-Seine | 5963 | 5411 | 11.44 | 68,246 | 5.30 | 1636 | 22,199 |
| 93 Seine-Saint-Denis | 5303 | 4957 | 10.14 | 53,779 | 4.17 | 1741 | 17,912 |
| 94 Val-de-Marne | 6168 | 5749 | 10.97 | 67,655 | 5.25 | 1784 | 20,451 |
| 95 Val-d'Oise | 3491 | 3214 | 10.07 | 35,155 | 2.73 | 660 | 8694 |
| Centre-Val de Loire | 3650 | 2959 | 11.11 | 40,551 | 3.15 | 713 | 9750 |
| 18 Cher | 345 | 269 | 12.54 | 4328 | 0.34 | 41 | 484 |
| 28 Eure-et-Loir | 776 | 701 | 11.90 | 9235 | 0.72 | 124 | 1847 |
| 36 Indre | 389 | 321 | 11.01 | 4281 | 0.33 | 47 | 453 |
| 37 Indre-et-Loire | 986 | 738 | 8.66 | 8535 | 0.66 | 226 | 2890 |
| 41 Loir-et-Cher | 428 | 393 | 12.63 | 5404 | 0.42 | 73 | 758 |
| 45 Loiret | 726 | 633 | 12.08 | 8768 | 0.68 | 202 | 3318 |
| Bourgogne-Franche-Comté | 5487 | 4802 | 11.04 | 60,581 | 4.70 | 1446 | 17,793 |
| 21 Côte-d'Or | 1257 | 1100 | 10.62 | 13,354 | 1.04 | 656 | 7500 |
| 25 Doubs | 1060 | 881 | 10.02 | 10,621 | 0.82 | 250 | 3268 |
| 39 Jura | 327 | 321 | 10.88 | 3559 | 0.28 | 62 | 437 |
| 58 Nièvre | 140 | 117 | 13.45 | 1883 | 0.15 | 22 | 395 |
| 70 Haute-Saône | 322 | 305 | 10.61 | 3416 | 0.27 | 107 | 933 |
| 71 Saône-et-Loire | 1100 | 917 | 9.58 | 10,534 | 0.82 | 150 | 1724 |
| 89 Yonne | 507 | 472 | 13.55 | 6872 | 0.53 | 90 | 1639 |
| 90 Territoire de Belfort | 774 | 766 | 13.36 | 10,342 | 0.80 | 109 | 1897 |
| Normandie | 3109 | 2651 | 11.04 | 34,331 | 2.66 | 655 | 8392 |
| 14 Calvados | 492 | 423 | 11.63 | 5721 | 0.44 | 134 | 1938 |
| 27 Eure | 458 | 398 | 9.20 | 4215 | 0.33 | 55 | 642 |
| 50 Manche | 278 | 229 | 10.69 | 2973 | 0.23 | 53 | 891 |
| 61 Orne | 432 | 369 | 12.51 | 5403 | 0.42 | 63 | 807 |
| 76 Seine-Maritime | 1449 | 1311 | 11.06 | 16,019 | 1.24 | 350 | 4114 |
| Hauts-de-France | 11,121 | 9295 | 10.38 | 115,424 | 8.96 | 3117 | 34,587 |
| 02 Aisne | 1485 | 1356 | 11.26 | 16,727 | 1.30 | 262 | 3451 |
| 59 Nord | 4348 | 3545 | 9.45 | 41,074 | 3.19 | 1303 | 14,300 |
| 60 Oise | 1948 | 1779 | 11.37 | 22,149 | 1.72 | 425 | 5169 |
| 62 Pas-de-Calais | 1879 | 1610 | 9.82 | 18,459 | 1.43 | 829 | 7564 |
| 80 Somme | 1461 | 1193 | 11.65 | 17,015 | 1.32 | 298 | 4103 |
| Grand Est | 17,879 | 14,656 | 11.15 | 199,426 | 15.48 | 4090 | 48,623 |
| 08 Ardennes | 276 | 246 | 10.56 | 2914 | 0.23 | 46 | 682 |
| 10 Aube | 504 | 460 | 13.24 | 6671 | 0.52 | 85 | 1073 |
| 51 Marne | 1308 | 1148 | 11.06 | 14,467 | 1.12 | 220 | 2922 |
| 52 Haute-Marne | 391 | 359 | 12.20 | 4771 | 0.37 | 71 | 1010 |
| 54 Meurthe-et-Moselle | 2020 | 1595 | 11.12 | 22,462 | 1.74 | 575 | 7169 |
| 55 Meuse | 521 | 415 | 11.74 | 6116 | 0.47 | 62 | 848 |
| 57 Moselle | 3778 | 3244 | 10.91 | 41,209 | 3.20 | 736 | 8283 |
| 67 Bas-Rhin | 4319 | 3383 | 10.66 | 46,054 | 3.57 | 931 | 13,366 |
| 68 Haut-Rhin | 3729 | 3321 | 11.88 | 44,314 | 3.44 | 1099 | 11,291 |
| 88 Vosges | 1033 | 960 | 10.11 | 10,448 | 0.81 | 265 | 1979 |
| Pays de la Loire | 3363 | 2912 | 10.65 | 35,826 | 2.78 | 590 | 7278 |
| 44 Loire-Atlantique | 1205 | 976 | 9.79 | 11,796 | 0.92 | 238 | 2735 |
| 49 Maine-et-Loire | 887 | 838 | 11.06 | 9809 | 0.76 | 186 | 2237 |
| 53 Mayenne | 230 | 201 | 13.62 | 3132 | 0.24 | 26 | 508 |
| 72 Sarthe | 574 | 507 | 11.65 | 6687 | 0.52 | 61 | 839 |
| 85 Vendée | 467 | 416 | 9.43 | 4402 | 0.34 | 79 | 959 |
| Bretagne | 1807 | 1592 | 10.97 | 19,830 | 1.54 | 450 | 5587 |
| 22 Côtes-d'Armor | 320 | 264 | 10.58 | 3384 | 0.26 | 66 | 521 |
| 29 Finistère | 373 | 335 | 11.34 | 4231 | 0.33 | 101 | 1329 |
| 35 Ille-et-Vilaine | 517 | 464 | 11.48 | 5936 | 0.46 | 132 | 1576 |
| 56 Morbihan | 597 | 551 | 10.52 | 6279 | 0.49 | 151 | 2161 |
| Nouvelle-Aquitaine | 3766 | 3051 | 10.29 | 38,739 | 3.01 | 969 | 12,028 |
| 16 Charente | 142 | 124 | 7.87 | 1117 | 0.09 | 35 | 353 |
| 17 Charente-Maritime | 280 | 235 | 12.02 | 3366 | 0.26 | 56 | 940 |
| 19 Corrèze | 251 | 219 | 11.14 | 2795 | 0.22 | 38 | 454 |
| 23 Creuse | 85 | 75 | 13.04 | 1108 | 0.09 | 41 | 420 |
| 24 Dordogne | 157 | 136 | 11.56 | 1815 | 0.14 | 17 | 243 |
| 33 Gironde | 1733 | 1307 | 9.70 | 16,810 | 1.30 | 463 | 5572 |
| 40 Landes | 108 | 105 | 11.71 | 1265 | 0.10 | 32 | 474 |
| 47 Lot-et-Garonne | 158 | 117 | 10.45 | 1651 | 0.13 | 24 | 329 |
| 64 Pyrénées-Atlantiques | 294 | 258 | 10.47 | 3077 | 0.24 | 60 | 784 |
| 79 Deux-Sèvres | 94 | 85 | 9.89 | 930 | 0.07 | 12 | 233 |
| 86 Vienne | 251 | 228 | 10.59 | 2657 | 0.21 | 69 | 831 |

(continued)

Table 2 (Continued)

| | Hospital stays | Patients | Mean stay duration (days) | Total days of hospital care | % of national total | Critical care stays | Total days of critical care |
|---|----------------|---------------|---------------------------|-----------------------------|---------------------|---------------------|-----------------------------|
| 87 Haute-Vienne | 213 | 198 | 10.08 | 2148 | 0.17 | 122 | 1395 |
| Occitanie | 4205 | 3588 | 11.17 | 46,952 | 3.64 | 1198 | 15,212 |
| 09 Ariège | 37 | 37 | 14.30 | 529 | 0.04 | 10 | 220 |
| 11 Aude | 384 | 344 | 12.00 | 4608 | 0.36 | 70 | 774 |
| 12 Aveyron | 207 | 171 | 7.29 | 1509 | 0.12 | 20 | 266 |
| 30 Gard | 446 | 411 | 14.29 | 6375 | 0.49 | 165 | 2010 |
| 31 Haute-Garonne | 913 | 745 | 11.58 | 10,571 | 0.82 | 372 | 4937 |
| 32 Gers | 226 | 199 | 12.43 | 2810 | 0.22 | 43 | 297 |
| 34 Hérault | 996 | 833 | 10.47 | 10,428 | 0.81 | 297 | 3471 |
| 46 Lot | 87 | 73 | 10.30 | 896 | 0.07 | 17 | 239 |
| 48 Lozère | 27 | 27 | 9.67 | 261 | 0.02 | 2 | 42 |
| 65 Hautes-Pyrénées | 190 | 171 | 12.04 | 2288 | 0.18 | 35 | 646 |
| 66 Pyrénées-Orientales | 406 | 379 | 8.43 | 3423 | 0.27 | 85 | 1041 |
| 81 Tarn | 218 | 193 | 11.04 | 2407 | 0.19 | 61 | 876 |
| 82 Tarn-et-Garonne | 68 | 64 | 12.46 | 847 | 0.07 | 21 | 393 |
| Auvergne-Rhône-Alpes | 12,369 | 10,382 | 11.05 | 136,688 | 10.61 | 2436 | 31,784 |
| 01 Ain | 695 | 620 | 9.36 | 6502 | 0.50 | 156 | 1336 |
| 03 Allier | 270 | 255 | 11.75 | 3173 | 0.25 | 49 | 799 |
| 07 Ardèche | 606 | 561 | 12.84 | 7784 | 0.60 | 74 | 1123 |
| 15 Cantal | 80 | 60 | 12.36 | 989 | 0.08 | 26 | 244 |
| 26 Drôme | 737 | 664 | 11.41 | 8412 | 0.65 | 156 | 2259 |
| 38 Isère | 1060 | 968 | 12.24 | 12,973 | 1.01 | 210 | 2376 |
| 42 Loire | 1756 | 1442 | 12.37 | 21,721 | 1.69 | 286 | 5302 |
| 43 Haute-Loire | 78 | 72 | 16.00 | 1248 | 0.10 | 13 | 256 |
| 63 Puy-de-Dôme | 460 | 403 | 9.33 | 4291 | 0.33 | 91 | 1314 |
| 69 Rhône | 4714 | 3845 | 10.79 | 50,872 | 3.95 | 1046 | 12,808 |
| 73 Savoie | 536 | 478 | 9.88 | 5297 | 0.41 | 98 | 1003 |
| 74 Haute-Savoie | 1377 | 1195 | 9.75 | 13,426 | 1.04 | 231 | 2964 |
| Provence-Alpes-Côte d'Azur | 6499 | 5529 | 10.80 | 701,92 | 5.45 | 1517 | 20,881 |
| 04 Alpes-de-Haute-Provence | 98 | 94 | 9.42 | 923 | 0.07 | 13 | 163 |
| 05 Hautes-Alpes | 159 | 147 | 9.76 | 1552 | 0.12 | 38 | 530 |
| 06 Alpes-Maritimes | 1 132 | 916 | 9.20 | 10,411 | 0.81 | 213 | 2835 |
| 13 Bouches-du-Rhône | 3755 | 3232 | 11.39 | 42,761 | 3.32 | 950 | 13,477 |
| 83 Var | 961 | 865 | 11.69 | 11,230 | 0.87 | 234 | 3065 |
| 84 Vaucluse | 394 | 337 | 8.41 | 3315 | 0.26 | 69 | 811 |
| Corse | 327 | 306 | 14.29 | 4673 | 0.36 | 75 | 1125 |
| 2A Corse-du-Sud | 229 | 212 | 15.92 | 3645 | 0.28 | 59 | 895 |
| 2B Haute-Corse | 98 | 94 | 10.49 | 1028 | 0.08 | 16 | 230 |
| DROM (Départements et régions d'outre-mer) | 1510 | 1395 | 9.63 | 14,541 | 1.13 | 287 | 3491 |
| 971 Guadeloupe | 238 | 214 | 10.27 | 2444 | 0.19 | 65 | 759 |
| 972 Martinique | 191 | 172 | 11.91 | 2275 | 0.18 | 58 | 948 |
| 973 Guyane | 538 | 521 | 9.09 | 4889 | 0.38 | 77 | 789 |
| 974 La Réunion | 259 | 236 | 8.84 | 2290 | 0.18 | 40 | 349 |
| 976 Mayotte | 284 | 282 | 9.31 | 2643 | 0.21 | 47 | 646 |

The COVID-19 crude mortality ratio (CMR) varied significantly across French regions and departments (Table 3), with the Grand Est region reporting the highest (57.91/100,000 inhabitants), and the overseas departments (DROM) the lowest (5.45/100,000). After standardisation for age and gender, the highest mortality rate (SMR) occurred in the Île-de-France region (72.80/100 000).

If the maximum weekly number of discharged patients was recorded in the week of April 6 ($n = 15,653$), the highest number of hospital deaths had occurred one week prior : March 30, with 3582 deaths (Fig. 2B). The weekly hospitalised case fatality rate (HCFR) ranged during the first wave from 12.8 % (35 deaths) during the week of March 2, to a maximum of 26.3 % (942 deaths) during the week of March 16, and was as low as 7.5 % (56 deaths) during the week of June 29 (Fig. 2C). The hospital case fatality rate (HCFR) rate throughout the study period likewise varied among French departments (Table 3.), with a maximum of 29.3 % (84 deaths out of 287 cases) in Cher and 25.9 % in Moselle (817 deaths out of 3155 cases), and a minimum of 3.4 % in La Reunion, albeit among a very low number of cases (7 deaths out of 206 cases).

Although mortality and incidence rates are highly correlated (Fig. 4A and B, $r = 0.969$ and $r = 0.973$), in one department, Moselle,

the mortality rate was higher than what would be expected based on this correlation, whereas in Guyane and Mayotte, the standardised mortality rate was lower than expected. While the HCFR tends to increase with CIR and CMR, the relationship is not linear, with a ceiling effect approximating 20 % (Fig. 4C and D). The Cher department, which exhibited the highest HCFR, nevertheless presented incidence rates below the national level and mortality rates within the range of the latter. In contrast, some departments (la Réunion, Guyane, Mayotte, Hautes-Alpes) had a lower HCFR than would have been expected based on their incidence rates.

4. Discussion

To our knowledge, this report is the first to detail the spatial and temporal distribution of COVID-19 hospitalisations in France from January to June 2020, period covering the first pandemic wave, on a nationwide level. Following the appearance of initial clusters in the east of France and north of Paris, the epidemic spread throughout the country, with different departments undergoing different epidemic progressions, as illustrated in this work. The nationwide lockdown, which began on March 17, slowed the epidemic, of which the

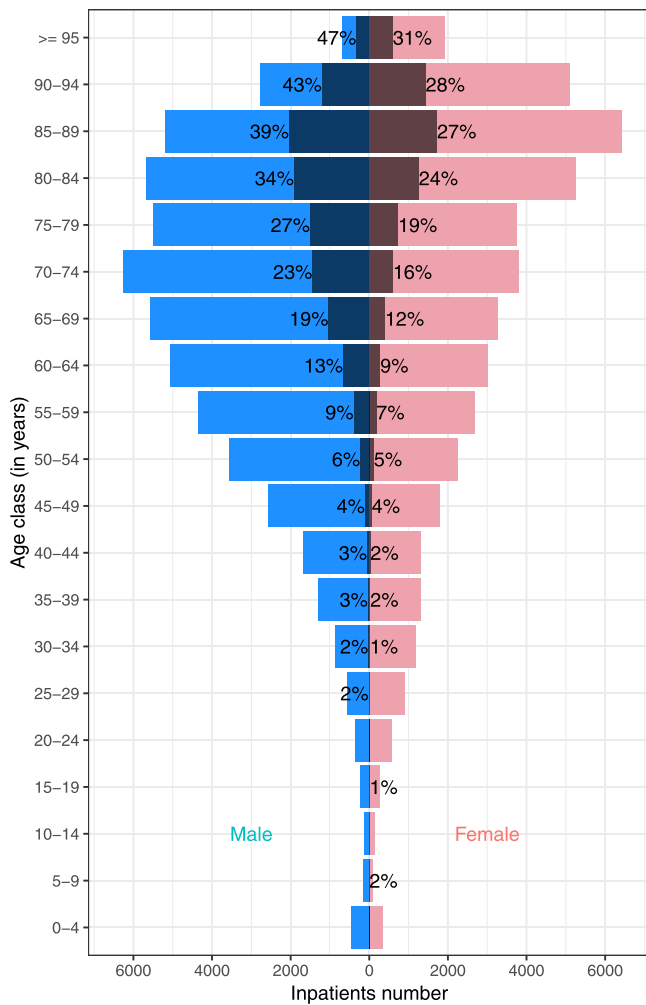


Fig. 1. Population age pyramids of COVID-19 hospitalisations from January to June 2020 in France. Hospitalized case fatality rates (HCFR) are given as percentages, and represented as grey shadows.

hospitalisation peak for almost all departments was reached during the week of March 23. Unfortunately, in some departments at the start of the national lockdown, the incidence rate of hospitalisation was already extremely high. Due to overwhelmed critical care capacities, some patients were transferred to other hospitals in France or even abroad. This was rendered possible by interregional cooperation and a lesser impact of the epidemic in some departments. Throughout the study period, 57 % of French departments never reached the threshold of a weekly rate of 20 hospitalisations per 100,000 inhabitants. The slower progression of the epidemic in those departments may have been due to their geographical location, far removed from the first clusters, and also to their lower density of population, which ranged in France from 3 (Guyane) to 1022 inhabitants per square kilometre (Île de France) [23].

The global dynamic of the first wave can be characterized as a four-week exponential increase, followed by a less rapid decrease over the course of ten weeks. One department, Guyane, had a limited number of cases from January to June 2020 whilst only in July did the epidemic peak arrive. The overseas location of this department (between Suriname and Brazil) could explain the belated occurrence of the first wave.

Among hospitalised patients, a greater number of deaths were observed at the beginning of the epidemic, which may be explained by initial lack of knowledge about the disease and the most appropriate care modalities ; limited CCU capacities may also have had an influence at the early stages [24], as did testing capacity, which was

limited at the onset of the pandemic. Conversely, decreased in-hospital mortality of COVID-19 patients throughout the study period may have been due to increased screening of patients, resulting in an increased number of cases detected before it was too late. As for the proportion of unconfirmed cases, it was higher among patients who spent at least one day in a CCU than among those who did not (28.0 % vs 21.1 %). Due to low availability of PCR tests until May 2020, a sizeable proportion of severe symptomatic cases may have been diagnosed based only on clinical and TDM evidence.

While the mortality rate of in-hospital COVID-19 cases was strongly correlated with the incidence rate, case fatality rates in hospitals displayed a ceiling effect approximating 20 to 25 %. This may have been due to effective hospital organisation, and more specifically, to flexibility ; when necessary, CCU capacities were scaled up, and medical evacuations to less affected departments were carried out ; these responses may have limited case fatality rates in hospitals. While the correlation between mortality and incidence was very strong, a few exceptions were highlighted, including Moselle, in which, given the level of incidence, mortality was higher than would have been expected. Excess mortality could have been due to level of vulnerability, particularly with regard to the pre-existing state of health of the population. Other determinants (socioeconomic, population density, overall health status, healthcare access...), which were not evaluated in our study, may partially account for the geographical differences in mortality [25]. They may also reflect the difficulty of providing patients with adequate treatment, at a time when, as in other countries, the French healthcare system was at saturation.

Several previously published nationwide studies have focused on the impact on hospitalisation of the first wave of the COVID-19 epidemic in France. They were rendered possible by the accessibility to research teams of the French healthcare system's two centralized databases : (1) the PMSI database, described in our studies, and (2) the SI-VIC system, which is used by health agencies to follow exceptional health crises in real time [26].

A recent study analysed COVID hospitalisation based on the SNDS database, which includes the PMSI [16]. Although this work has some similarities with ours, its main objective was to estimate risk of COVID-19 hospitalisation and mortality among different populations, but without focusing on the temporal and geographical evolution of the first wave. The number of inpatients was 11 % lower (87,809 vs 98,366), probably due to four factors : the inclusion period was shorter, data extraction was made earlier (September 2020 vs January 2021), patients with missing demographic data were discarded, and they only included patients whose COVID codes were considered as principal, whereas we took also associated diagnosis into account.

We found three analyses drawn from the SI-VIC database on French COVID hospitalisations during the first wave [14,15,27]. The main results were similar to ours. However, direct comparison is difficult due to several key differences. Our study included data of inpatients over a longer period, from January to June 2020, while these studies dealt only with the lockdown period (March 17 – May 10). They did not consider the DROM departments, which experienced a much different epidemic dynamic compared to mainland France, as shown in the present study. Furthermore, due to the real-time functioning of the SI-VIC database [28], there were few retrospective corrections (e.g., adding missing cases having occurred prior to March). By contrast, in the PMSI database each hospital was asked to retrospectively review possible COVID cases and to add the appropriate CIM-10 identification codes. In addition, the definition of probable COVID-19 cases was different. To be registered as a probable case in the PMSI, and thereby counted as a COVID-19 case, a positive chest computed tomography (CT) result had to be corroborated with specific clinical features. In the SI-VIC database, the CT result alone was sufficient. This definition may have overestimated the number of cases measured in the SI-VIC, as the specificity of the chest CT has been shown not to be optimal, with varying predictive values across time [29,30].

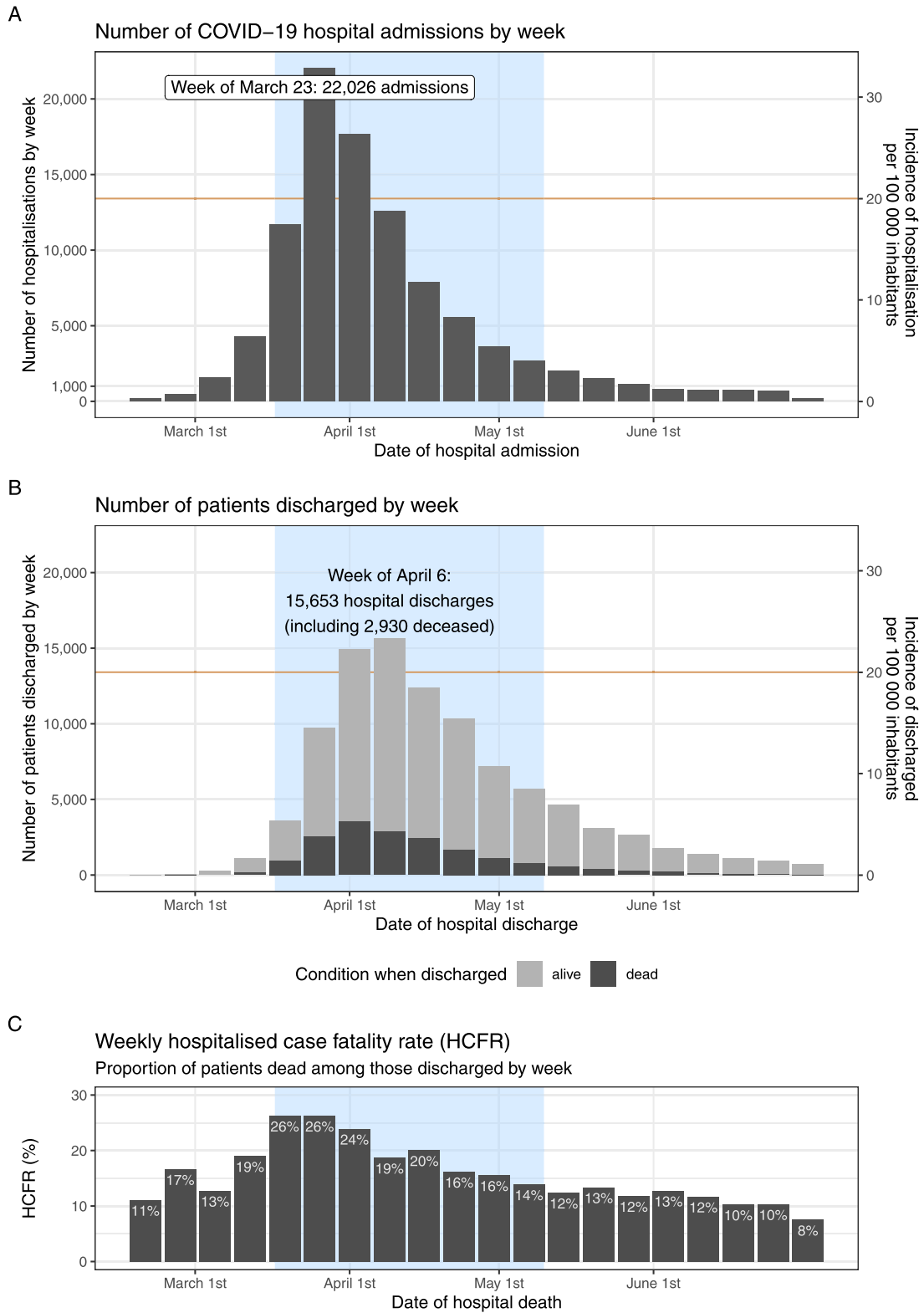


Fig. 2. Evolution by week of (A) the number and the incidence of COVID-19 hospitalisations (B) the number and incidence of COVID-19 patients discharged alive (grey) or deceased (black) and (C) the weekly hospitalised case fatality rates, calculated as the proportion of deaths among all discharged COVID-19 patients. The shaded blue area represents the lockdown period, from March 17 to May 10.

Table 3

Incidence, mortality and fatality for patients hospitalised with COVID-19 in France from January to June 2020, according to region of residency.

| Region/Department | Population | Cases | CIR | SIR | Deaths | CMR | SMR | HCFR (%) |
|--------------------------------|------------|--------|--------|--------|--------|-------|--------|----------|
| France* | 67,063,703 | 98,005 | 146.14 | | 18,387 | 27.42 | | 18.76 |
| Ile-de-France | 12,278,210 | 35,618 | 290.09 | 349.67 | 6790 | 55.30 | 72.80 | 19.06 |
| 75 Paris | 2,148,271 | 6891 | 320.77 | 363.61 | 1337 | 62.24 | 73.42 | 19.40 |
| 77 Seine-et-Marne | 1,423,607 | 3391 | 238.20 | 290.82 | 634 | 44.53 | 61.10 | 18.70 |
| 78 Yvelines | 1,448,625 | 3084 | 212.89 | 239.02 | 588 | 40.59 | 47.60 | 19.07 |
| 91 Essonne | 1,319,401 | 3404 | 258.00 | 307.22 | 612 | 46.38 | 60.52 | 17.98 |
| 92 Hauts-de-Seine | 1,613,762 | 4520 | 280.09 | 331.36 | 845 | 52.36 | 65.85 | 18.69 |
| 93 Seine-Saint-Denis | 1,670,149 | 6250 | 374.22 | 520.74 | 1192 | 71.37 | 119.28 | 19.07 |
| 94 Val-de-Marne | 1,406,041 | 4568 | 324.88 | 388.22 | 886 | 63.01 | 81.52 | 19.40 |
| 95 Val-d'Oise | 1,248,354 | 3510 | 281.17 | 354.75 | 696 | 55.75 | 79.05 | 19.83 |
| Centre-Val de Loire | 2,559,073 | 2937 | 114.77 | 104.33 | 517 | 20.20 | 17.42 | 17.60 |
| 18 Cher | 296,404 | 287 | 96.83 | 77.89 | 84 | 28.34 | 21.53 | 29.27 |
| 28 Eure-et-Loir | 429,425 | 682 | 158.82 | 151.90 | 116 | 27.01 | 24.75 | 17.01 |
| 36 Indre | 217,139 | 336 | 154.74 | 120.01 | 86 | 39.61 | 27.44 | 25.60 |
| 37 Indre-et-Loire | 605,380 | 597 | 98.62 | 91.43 | 81 | 13.38 | 11.87 | 13.57 |
| 41 Loir-et-Cher | 327,835 | 410 | 125.06 | 103.36 | 71 | 21.66 | 16.56 | 17.32 |
| 45 Loiret | 682,890 | 625 | 91.52 | 91.87 | 79 | 11.57 | 11.49 | 12.64 |
| Bourgogne-Franche-Comté | 2,783,039 | 4706 | 169.10 | 151.33 | 965 | 34.67 | 29.66 | 20.51 |
| 21 Côte-d'Or | 532,886 | 1031 | 193.47 | 185.84 | 213 | 39.97 | 37.61 | 20.66 |
| 25 Doubs | 539,449 | 1144 | 212.07 | 215.31 | 221 | 40.97 | 41.52 | 19.32 |
| 39 Jura | 257,849 | 345 | 133.80 | 115.78 | 59 | 22.88 | 18.73 | 17.10 |
| 58 Nièvre | 199,596 | 142 | 71.14 | 54.89 | 27 | 13.53 | 8.98 | 19.01 |
| 70 Haute-Saône | 233,194 | 456 | 195.55 | 173.48 | 98 | 42.03 | 36.53 | 21.49 |
| 71 Saône-et-Loire | 547,824 | 828 | 151.14 | 124.53 | 175 | 31.94 | 24.01 | 21.14 |
| 89 Yonne | 332,096 | 474 | 142.73 | 124.13 | 101 | 30.41 | 25.04 | 21.31 |
| 90 Territoire de Belfort | 140,145 | 286 | 204.07 | 203.02 | 71 | 50.66 | 50.40 | 24.83 |
| Normandie | 3,303,500 | 2604 | 78.83 | 75.11 | 453 | 13.71 | 12.75 | 17.40 |
| 14 Calvados | 691,453 | 345 | 49.89 | 47.40 | 58 | 8.39 | 7.75 | 16.81 |
| 27 Eure | 600,687 | 575 | 95.72 | 98.53 | 113 | 18.81 | 19.86 | 19.65 |
| 50 Manche | 490,669 | 236 | 48.10 | 40.40 | 45 | 9.17 | 7.08 | 19.07 |
| 61 Orne | 276,903 | 315 | 113.76 | 91.20 | 46 | 16.61 | 12.44 | 14.60 |
| 76 Seine-Maritime | 1,243,788 | 1,133 | 91.09 | 91.76 | 191 | 15.36 | 15.60 | 16.86 |
| Hauts-de-France | 5,962,662 | 9364 | 157.04 | 172.96 | 1981 | 33.22 | 38.69 | 21.16 |
| 02 Aisne | 526,050 | 1332 | 253.21 | 250.50 | 324 | 61.59 | 60.95 | 24.32 |
| 59 Nord | 2,588,988 | 3332 | 128.70 | 147.16 | 628 | 24.26 | 29.92 | 18.85 |
| 60 Oise | 825,077 | 1931 | 234.04 | 266.03 | 433 | 52.48 | 64.79 | 22.42 |
| 62 Pas-de-Calais | 1,452,778 | 1663 | 114.47 | 122.61 | 338 | 23.27 | 26.45 | 20.32 |
| 80 Somme | 569,769 | 1106 | 194.11 | 199.86 | 258 | 45.28 | 47.42 | 23.33 |
| Grand Est | 5,511,747 | 14,640 | 265.61 | 262.39 | 3192 | 57.91 | 57.98 | 21.80 |
| 08 Ardennes | 265,531 | 256 | 96.41 | 89.65 | 55 | 20.71 | 19.21 | 21.48 |
| 10 Aube | 309,907 | 463 | 149.40 | 143.07 | 101 | 32.59 | 30.48 | 21.81 |
| 51 Marne | 563,823 | 1092 | 193.68 | 200.88 | 245 | 43.45 | 45.97 | 22.44 |
| 52 Haute-Marne | 169,250 | 314 | 185.52 | 153.19 | 79 | 46.68 | 36.93 | 25.16 |
| 54 Meurthe-et-Moselle | 730,398 | 1330 | 182.09 | 186.83 | 262 | 35.87 | 37.34 | 19.70 |
| 55 Meuse | 181,641 | 473 | 260.40 | 234.92 | 90 | 49.55 | 43.82 | 19.03 |
| 57 Moselle | 1,035,866 | 3155 | 304.58 | 304.72 | 817 | 78.87 | 81.06 | 25.90 |
| 67 Bas-Rhin | 1,132,607 | 3209 | 283.33 | 295.60 | 579 | 51.12 | 55.76 | 18.04 |
| 68 Haut-Rhin | 763,204 | 3361 | 440.38 | 437.02 | 727 | 95.26 | 96.07 | 21.63 |
| 88 Vosges | 359,520 | 987 | 274.53 | 232.45 | 237 | 65.92 | 54.38 | 24.01 |
| Pays de la Loire | 3,801,797 | 2830 | 74.44 | 72.22 | 459 | 12.07 | 11.40 | 16.22 |
| 44 Loire-Atlantique | 1,437,137 | 875 | 60.88 | 66.20 | 157 | 10.92 | 12.38 | 17.94 |
| 49 Maine-et-Loire | 815,881 | 831 | 101.85 | 96.22 | 138 | 16.91 | 15.02 | 16.61 |
| 53 Mayenne | 305,365 | 204 | 66.81 | 59.55 | 40 | 13.10 | 10.78 | 19.61 |
| 72 Sarthe | 560,227 | 507 | 90.50 | 82.74 | 78 | 13.92 | 11.94 | 15.38 |
| 85 Vendée | 683,187 | 413 | 60.45 | 54.42 | 46 | 6.73 | 5.77 | 11.14 |
| Bretagne | 3,340,379 | 1501 | 44.94 | 42.15 | 258 | 7.72 | 7.01 | 17.19 |
| 22 Côtes-d'Armor | 596,186 | 311 | 52.16 | 44.22 | 48 | 8.05 | 6.20 | 15.43 |
| 29 Finistère | 906,554 | 295 | 32.54 | 30.25 | 52 | 5.74 | 5.08 | 17.63 |
| 35 Ille-et-Vilaine | 1,082,073 | 395 | 36.50 | 38.90 | 71 | 6.56 | 7.18 | 17.97 |
| 56 Morbihan | 755,566 | 500 | 66.18 | 57.94 | 87 | 11.51 | 9.71 | 17.40 |
| Nouvelle-Aquitaine | 5,999,982 | 2893 | 48.22 | 42.63 | 481 | 8.02 | 6.61 | 16.63 |
| 16 Charente | 348,180 | 116 | 33.32 | 27.09 | 18 | 5.17 | 4.01 | 15.52 |
| 17 Charente-Maritime | 647,080 | 242 | 37.40 | 30.02 | 55 | 8.50 | 6.28 | 22.73 |
| 19 Corrèze | 240,336 | 201 | 83.63 | 67.34 | 37 | 15.40 | 11.21 | 18.41 |
| 23 Creuse | 116,270 | 56 | 48.16 | 38.31 | 8 | 6.88 | 4.10 | 14.29 |
| 24 Dordogne | 408,393 | 167 | 40.89 | 32.29 | 25 | 6.12 | 4.16 | 14.97 |
| 33 Gironde | 1,633,440 | 1168 | 71.51 | 74.25 | 186 | 11.39 | 12.04 | 15.92 |
| 40 Landes | 411,979 | 130 | 31.56 | 27.50 | 18 | 4.37 | 3.76 | 13.85 |
| 47 Lot-et-Garonne | 330,336 | 115 | 34.81 | 28.69 | 16 | 4.84 | 3.54 | 13.91 |
| 64 Pyrénées-Atlantiques | 683,169 | 234 | 34.25 | 29.53 | 31 | 4.54 | 3.66 | 13.25 |
| 79 Deux-Sèvres | 372,627 | 104 | 27.91 | 24.54 | 21 | 5.64 | 4.55 | 20.19 |
| 86 Vienne | 437,398 | 187 | 42.75 | 39.37 | 35 | 8.00 | 6.82 | 18.72 |
| 87 Haute-Vienne | 370,774 | 173 | 46.66 | 39.89 | 31 | 8.36 | 6.45 | 17.92 |

(continued)

Table 3 (Continued)

| Region/Department | Population | Cases | CIR | SIR | Deaths | CMR | SMR | HCFR (%) |
|-----------------------------------|------------|--------|--------|--------|--------|-------|-------|----------|
| Occitanie | 5,924,858 | 3556 | 60.02 | 55.45 | 540 | 9.11 | 7.96 | 15.19 |
| 09 Ariège | 152,398 | 41 | 26.90 | 22.82 | 3 | 1.97 | 1.51 | 7.32 |
| 11 Aude | 372,705 | 358 | 96.05 | 77.91 | 72 | 19.32 | 14.36 | 20.11 |
| 12 Aveyron | 278,360 | 178 | 63.95 | 50.66 | 26 | 9.34 | 6.43 | 14.61 |
| 30 Gard | 748,468 | 459 | 61.33 | 55.75 | 84 | 11.22 | 9.90 | 18.30 |
| 31 Haute-Garonne | 1,400,935 | 658 | 46.97 | 52.47 | 79 | 5.64 | 6.73 | 12.01 |
| 32 Gers | 190,040 | 212 | 111.56 | 85.79 | 34 | 17.89 | 11.65 | 16.04 |
| 34 Hérault | 1,176,145 | 753 | 64.02 | 62.59 | 124 | 10.54 | 9.99 | 16.47 |
| 46 Lot | 173,166 | 72 | 41.58 | 32.27 | 12 | 6.93 | 4.42 | 16.67 |
| 48 Lozère | 76,286 | 29 | 38.01 | 31.20 | 3 | 3.93 | 2.95 | 10.34 |
| 65 Hautes-Pyrénées | 226,839 | 161 | 70.98 | 57.42 | 24 | 10.58 | 7.88 | 14.91 |
| 66 Pyrénées-Orientales | 479,000 | 368 | 76.83 | 69.97 | 40 | 8.35 | 6.68 | 10.87 |
| 81 Tarn | 387,898 | 199 | 51.30 | 41.79 | 30 | 7.73 | 5.68 | 15.08 |
| 82 Tarn-et-Garonne | 262,618 | 68 | 25.89 | 24.37 | 9 | 3.43 | 3.00 | 13.24 |
| Auvergne-Rhône-Alpes | 8,032,377 | 10,353 | 128.89 | 129.14 | 1743 | 21.70 | 21.69 | 16.84 |
| 01 Ain | 656,955 | 898 | 136.69 | 148.40 | 156 | 23.75 | 26.92 | 17.37 |
| 03 Allier | 331,315 | 250 | 75.46 | 61.40 | 47 | 14.19 | 10.18 | 18.80 |
| 07 Ardèche | 326,875 | 572 | 174.99 | 146.04 | 117 | 35.79 | 28.83 | 20.45 |
| 15 Cantal | 142,811 | 57 | 39.91 | 30.42 | 9 | 6.30 | 4.29 | 15.79 |
| 26 Drôme | 520,560 | 614 | 117.95 | 110.26 | 126 | 24.20 | 22.17 | 20.52 |
| 38 Isère | 1,264,979 | 1013 | 80.08 | 85.43 | 175 | 13.83 | 15.26 | 17.28 |
| 42 Loire | 764,737 | 1353 | 176.92 | 163.99 | 240 | 31.38 | 28.09 | 17.74 |
| 43 Haute-Loire | 226,901 | 125 | 55.09 | 46.89 | 18 | 7.93 | 6.58 | 14.40 |
| 63 Puy-de-Dôme | 660,240 | 359 | 54.37 | 51.99 | 46 | 6.97 | 6.51 | 12.81 |
| 69 Rhône | 1,876,051 | 3571 | 190.35 | 214.31 | 581 | 30.97 | 35.10 | 16.27 |
| 73 Savoie | 432,548 | 436 | 100.80 | 96.29 | 65 | 15.03 | 14.09 | 14.91 |
| 74 Haute-Savoie | 828,405 | 1105 | 133.39 | 150.34 | 163 | 19.68 | 24.01 | 14.75 |
| Provence-Alpes-Côte d'Azur | 5,055,651 | 5426 | 107.33 | 98.35 | 852 | 16.85 | 14.53 | 15.70 |
| 04 Alpes-de-Haute-Provence | 165,197 | 108 | 65.38 | 54.17 | 20 | 12.11 | 9.36 | 18.52 |
| 05 Hautes-Alpes | 141,756 | 130 | 91.71 | 81.18 | 11 | 7.76 | 6.13 | 8.46 |
| 06 Alpes-Maritimes | 1,079,396 | 886 | 82.08 | 70.55 | 154 | 14.27 | 10.94 | 17.38 |
| 13 Bouches-du-Rhône | 2,034,469 | 3041 | 149.47 | 147.84 | 474 | 23.30 | 22.70 | 15.59 |
| 83 Var | 1,073,836 | 917 | 85.39 | 73.19 | 136 | 12.66 | 10.05 | 14.83 |
| 84 Vaucluse | 560,997 | 344 | 61.32 | 57.93 | 57 | 10.16 | 9.28 | 16.57 |
| Corse | 344,679 | 206 | 59.77 | 52.75 | 38 | 11.02 | 9.21 | 18.45 |
| 2A Corse-du-Sud | 162,421 | 109 | 67.11 | 57.34 | 23 | 14.16 | 11.46 | 21.10 |
| 2B Haute-Corse | 182,258 | 97 | 53.22 | 48.43 | 15 | 8.23 | 7.08 | 15.46 |
| DROM | 2,165,749 | 1371 | 63.30 | 74.68 | 118 | 5.45 | 7.96 | 8.61 |
| 971 Guadeloupe | 376,879 | 214 | 56.78 | 55.22 | 33 | 8.76 | 8.60 | 15.42 |
| 972 Martinique | 358,749 | 162 | 45.16 | 40.77 | 22 | 6.13 | 5.48 | 13.58 |
| 973 Guyane | 290,691 | 521 | 179.23 | 310.19 | 35 | 12.04 | 35.06 | 6.72 |
| 974 La Réunion | 859,959 | 206 | 23.95 | 27.34 | 7 | 0.81 | 1.50 | 3.40 |
| 976 Mayotte | 279,471 | 268 | 95.90 | 351.82 | 21 | 7.51 | 50.82 | 7.84 |

* Patients without a valid zip code ($n = 361$, 0.4 %) were excluded from this analysis. CIR = crude incidence ratio, SIR = standardized (by age and sex) incidence ratio, CMR = crude in-hospital mortality ratio, SMR = standardized (by age and sex) mortality ratio, HCFR = hospitalized case fatality rate, DROM = Départements et régions d'outre-mer.

Other works have also used data drawn from the PMSI to assess the impact of the first wave in France. However, they were focused on highly specific topics, such as the evolution of hospitalisations for myocardial infarctions, stroke and self-harm ; hospitalised case fatality rate in ICUs ; and comparison to the influenza epidemic [31–36].

In a German study based on nationwide administrative healthcare data, the number of hospitalisations for COVID-19 was smaller, with an incidence rate of 12/100,000 inhabitants, ten times less than in France [12]. As in our study, care sequences were analysed. However, the inclusion criteria were more restricted : A shorter study period (February 28 to April 19), patients over the age of 18, covered by only one of the healthcare funds in Germany (representing approximately 32 % of the German population) and only patients with positive tests, whilst our study also included probable cases (representing 25.8 % of the patients included). On April 19, as the number of cases in the general population was lower in Germany (174/100,000 inhabitants) than in France (225/100,000), it is not surprising that in-hospital incidence in Germany was likewise lower than in France [37]. Despite these differences, median age of hospitalised patients (72 years in Germany, compared to 71 in France) and mean stay duration were similar (10 days in Germany, 9 days in France). However, the case fatality rate was higher in Germany (22 %) than in France (19 %), notwithstanding a higher number of ICU beds in Germany.

In England, a nationwide analysis was performed using the Hospital Episode Statistics (HES) dataset [11]. The number of included patients (91,541 vs 98,366), sex ratio (1.24 vs 1.16) and age distribution were similar to those in our study. However, the number of in-hospital deaths (28,200 vs 18,447) was significantly higher, affecting all age strata. It is worth noting that this paper included each patient's first hospitalisation, and did not consider care sequences.

Outside of Europe, in Brazil, a nationwide study included 254,288 inpatients hospitalised between February and August 2020 [13]. This geographical and temporal analysis was based on a comprehensive database, and focused on cases confirmed by RT-PCR. The results were quite different from those recorded in France. Patients were younger (median 61y vs 71y), the incidence of hospitalised confirmed cases was higher (120 vs 109/100,000 inhabitants), the proportion of hospitalised patients admitted to a CCU was higher (39 % vs 28 %) and the hospitalised case fatality rate was twice as high (38 % vs 20 %).

Some limitations of our study must be addressed. First, the PMSI database has been designed not for epidemiology purposes, but for funding allocation. As a result, the quality of the medical information may vary, according to the relation between coding and funding. However, we remain confident in COVID-19 coding, given that specific, emergency ICD-10 codes for COVID-19 were specially created

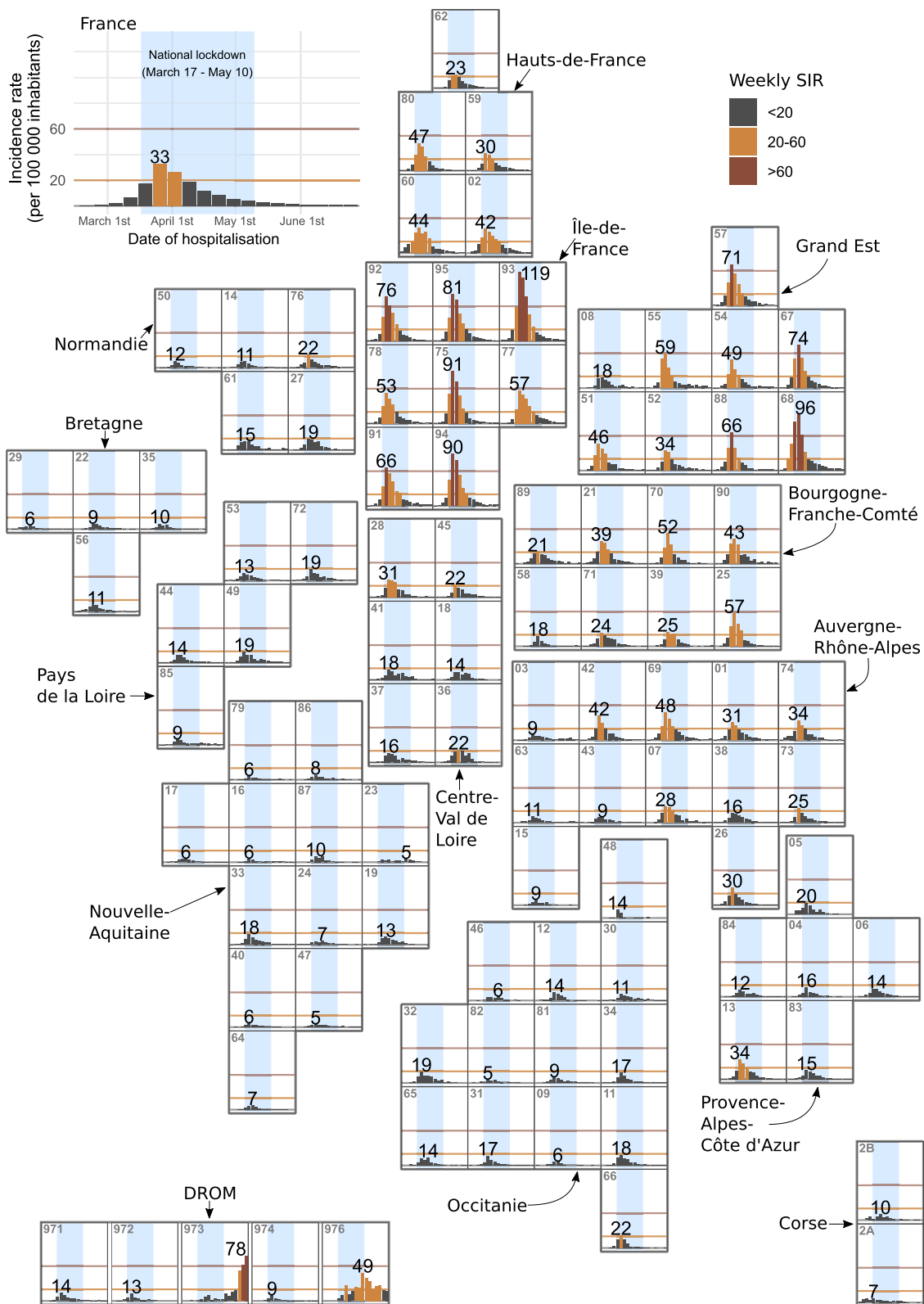


Fig. 3. Map of France with weekly standardised incidence of COVID-19 hospitalisation according to the patient's department of residence. Each small panel represents a French department, and is positioned approximately so as to elucidate the spatial connections between the different departments. The number at the top left corner of each panel is the department number. The shaded blue area represents the lockdown period, from March 17 to May 10. We considered two thresholds to define the beginning and the end of the wave : 20 (orange line) and 60 (red line)/100 000 inhabitants hospitalised per week. The top left panel represents nationwide incidence by week.

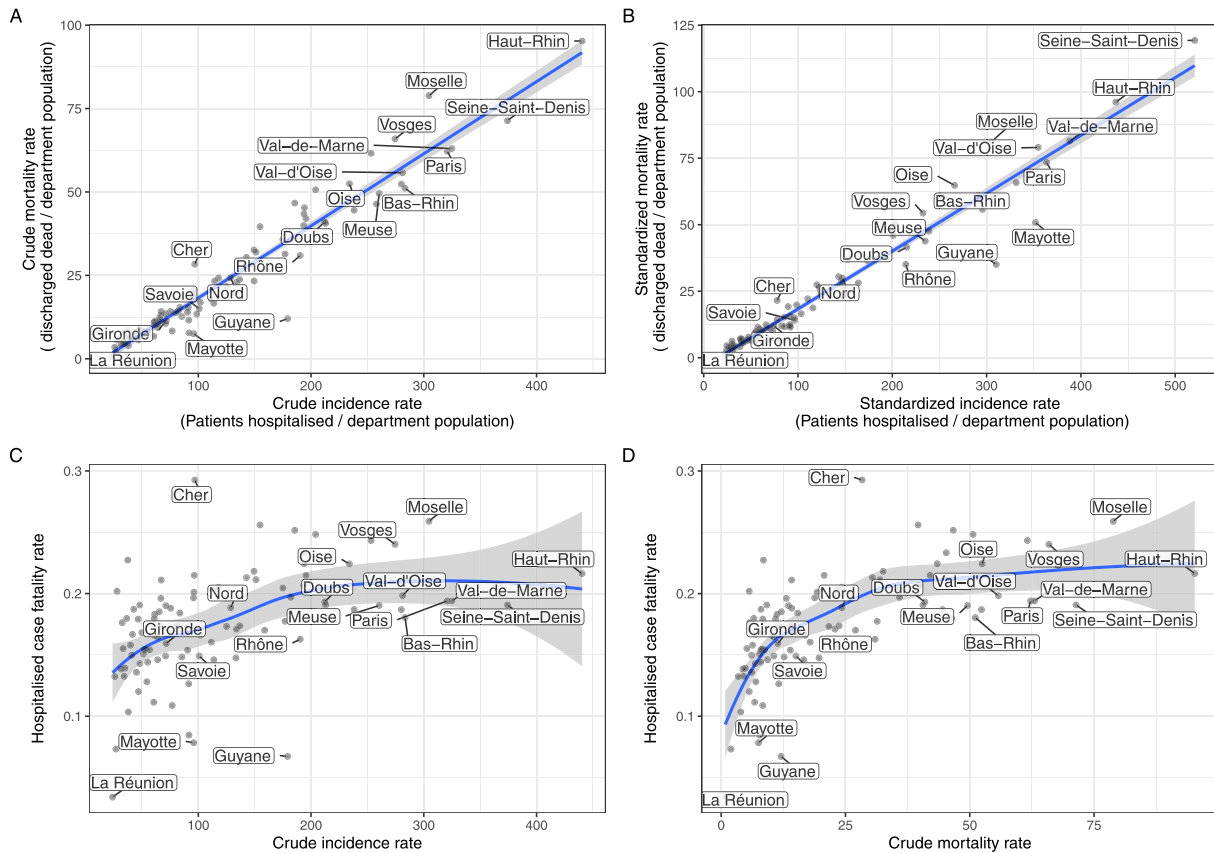


Fig. 4. Correlations between (A) CMR and CIR, (B) SMR and SIR, (C) HCFR and CIR, (D) HCFR and CMR. Each department is represented by a black dot and labelled. For panels (A) and (B), where CIR and SIR are considered, linear regression is represented by a turquoise line, with prediction limits for the individual predicted values shown as blue lines. For panels (C) and (D), where HCFR is considered, penalised B-spline curve is represented by a turquoise line, with prediction limits for the individual predicted values shown as blue lines.
 CIR = crude incidence ratio, SIR = standardised (by age and sex) incidence ratio, CMR = crude in-hospital mortality ratio, SMR = standardised (by age and sex) mortality ratio, HCFR = hospitalised case fatality rate.

by the WHO [38]. The ATIH circulated the coding rules to all medical information departments, which are responsible in all hospitals for data quality and completeness.

Second, specification of the municipality of residence to locate incident cases of COVID-19 may be imprecise ; some patients hospitalised during the epidemic may have been living outside of their official department of residence, or may have been hospitalised outside of the latter. Moreover, patients residing in a foreign country could not be assigned to a French department, even though they were admitted to a French hospital. That said, they comprise only a limited number of cases ($n = 361, 0.4\%$), which could barely change the results, and one hospital in the island of Corsica represented 103 (28.5%) of these cases, which may be due to erroneous data transmission or to a high number of foreigners in this island, which is close to Italy. Despite this exception, municipality of residence remains more appropriate than hospital location as a means of calculating incidence rates, because the reference population at a departmental level is clearly defined, whereas the catchment population of a hospital is not.

Third, this study focuses on hospitalisations in short-stay hospitals, which means that mortality in post-acute and rehabilitation facilities, in retirement homes, or at home was not assessed.

Our study nonetheless has several strengths.

First, it is based on comprehensive national data from all French public and private hospitals. We considered care sequences as opposed to isolated hospital stays. Due to transfers of patients between different hospitals, or between different sites of the same hospital in the case of larger institutions, a simple count of hospital stays would have resulted in overestimation of cases by

approximately 19 %, and underestimation of mortality rates, as well. Because the raw data include the date but not the exact time of discharge or hospitalisation, two hospital stays were considered to be contiguous if they were separated by one day or less. This way, it was possible to capture cases of transfers whereby the patient was discharged one day from a given hospital and admitted the next day to a second hospital.

Second, although analysis at a regional and departmental level is difficult to interpret, it more accurately characterizes the spatial and temporal dynamics of the epidemic.

Third, as age and sex were identified as the main risk factors for COVID-19 disease severity and death, we presented both the crude and standardised rates, the objective being to facilitate comparison despite demographic differences between different departments or regions [39].

Given the quality of the PMSI data, which covers all types of hospitals throughout the country, we were able to describe the dynamics of the first wave of COVID-19 hospitalisations in France. Our study highlights major geographical and temporal variability, which would have remained undetected in nationwide global analyses. When data are available, extension of this study by analysis of the second and third waves will contribute to understanding of the subsequent spread of the epidemic.

4.1. Data sharing

The PMSI database was made available by the hospital information technology agency (ATI. The National Commission for Information Technologies and Liberties (Commission Nationale de

l'Informatique et des Libertés, CNIL) approved use of this data by our department. While we are not permitted to share these data, PMSI data from ATIH are available to researchers who meet the criteria for access, upon request to the CNIL.

Authors' contributions

All of the authors took part in the design and drafting of the protocol. XL, AB and EO extracted the relevant data from the nationwide PMSI data base. JM, ST, PT and FB carried out data analysis. FS, VG et ML provided advice on the analyses. All of the authors were involved in interpretation of the data and validation of the manuscript.

Ties of interest

The authors have no ties of interest to declare.

Funding sources

No financing was solicited for the conduct of this study.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi : 10.1016/j.respe.2022.08.008.

References

- [1] Wu F, Zhao S, Yu B, Chen YM, Wang W, Song ZG, et al. A new coronavirus associated with human respiratory disease in China. *Nature* 2020;579(7798):265–9.
- [2] WHO. Novel Coronavirus – China - disease outbreak news: update . WHO. World Health Organization; 2020 [cited 2021 Feb 17]. Available from: <https://www.who.int/emergencies/disease-outbreak-news/item/2020-DON233>
- [3] Spiteri G, Fielding J, Diercke M, Campese C, Enouf V, Gaymard A, et al. First cases of coronavirus disease 2019 (COVID-19) in the WHO European region, 24 January to 21 February 2020. *Eurosurveill* 2020;25(9):2000178.
- [4] Carrat F, Figoni J, Henny J, Desclos JC, Kab S, de Lamballerie X, et al. Evidence of early circulation of SARS-CoV-2 in France: findings from the population-based "CONSTANCES" cohort. *Eur J Epidemiol* 2021;36(2):219–22.
- [5] Bernard Stoecklin S, Rolland P, Silue Y, Mailles A, Campese C, Simonon A, et al. First cases of coronavirus disease 2019 (COVID-19) in France: surveillance, investigations and control measures, January 2020. *Eurosurveill* 2020;25(6).
- [6] Fontanet A, Tondeur L, Grant R, Temmam S, Mader Y, Bigot T, et al. SARS-CoV-2 infection in schools in a northern French city: a retrospective serological cohort study in an area of high transmission, France, January to April 2020. *Eurosurveill* 2021;26(15):2001695.
- [7] Danis K, Epaulard O, Bénét T, Gaymard A, Campoy S, Botelho-Nevers E, et al. Cluster of coronavirus disease 2019 (COVID-19) in the French Alps, February 2020. *Clin Infect Dis* 2020;71(15):825–32.
- [8] Gerbaud L, Guiguet-Auclair C, Breyse F, Odoul J, Ouchchane L, Peterschmitt J, et al. Hospital and population-based evidence for COVID-19 early circulation in the East of France. *Int J Environ Res Public Health* 2020;17(19):7175.
- [9] WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. [cited 2021 Feb 17]. Available from: <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19-11-march-2020>
- [10] Cauchemez S, Kiem CT, Paireau J, Rolland P, Fontanet A. Lockdown impact on COVID-19 epidemics in regions across metropolitan France. *Lancet* 2020 10;396(10257):1068–9.
- [11] Navaratnam AV, Gray WK, Day J, Wendon J, Briggs TWR. Patient factors and temporal trends associated with COVID-19 in-hospital mortality in England: an observational study using administrative data. *Lancet Respir Med* 2021;9(4):397–406.
- [12] Karagiannidis C, Mostert C, Hentschker C, Voshhaar T, Malzahn J, Schillinger G, et al. Case characteristics, resource use, and outcomes of 10 021 patients with COVID-19 admitted to 920 German hospitals: an observational study. *Lancet Respir Med* 2020;8(9):853–62.
- [13] Ranzani OT, Bastos LSL, Gelli JGM, Marchesi JF, Baião F, Hamacher S, et al. Characterisation of the first 250 000 hospital admissions for COVID-19 in Brazil: a retrospective analysis of nationwide data. *Lancet Respir Med* 2021;9(4):407–18.
- [14] Salje H, Kiem CT, Lefrancq N, Courtejoie N, Bosetti P, Paireau J, et al. Estimating the burden of SARS-CoV-2 in France. *Sci* 2020;369(6500):208–11.
- [15] Gaudart J, Landier J, Huiart L, Legendre E, Lehot L, Bendiane MK, et al. Factors associated with the spatial heterogeneity of the first wave of COVID-19 in France: a nationwide geo-epidemiological study. *Lancet Public Health* 2021;6(4):e222–31.
- [16] Semenzato L, Botton J, Drouin J, Cuenot F, Dray-Spira R, Weill A, et al. Chronic diseases, health conditions and risk of COVID-19-related hospitalization and in-hospital mortality during the first wave of the epidemic in France: a cohort study of 66 million people. *Lancet Reg Health - Eur* 2021;8:100158.
- [17] Boudemaghe T, Belhadj I. Data resource profile: the French national uniform hospital discharge data set database (PMSI). *Int J Epidemiol* 2017;46(2):392–392d.
- [18] ATIH. Mise à jour des consignes de codage des séjours COVID-19. 2020 [cited 2021 Feb 12]. Available from: <https://www.atih.sante.fr/mise-jour-des-consignes-de-codage-des-sejours-covid-19>
- [19] Ouattara E, Bruandet A, Borde A, Lenne X, Binder-Foucard F, Le-bourhis-zaimi M, et al. Risk factors of mortality among patients hospitalised with COVID-19 in a critical care or hospital care unit: analysis of the French national medicoadministrative database. *BMJ Open Respir Res* 2021;8(1):e001002.
- [20] INSEE. Estimation de la population au 1er janvier 2021 - Séries par région, département, sexe et âge de 1975 à 2021 [Internet]. Institut national de la statistique et des études économiques. 2021 [cited 2021 Feb 12]. Available from: <https://www.insee.fr/fr/statistiques/1893198>
- [21] R Core Team. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2019. Available from: <https://www.R-project.org>.
- [22] Wickham H, Averick M, Bryan J, Chang W, McGowan L, François R, et al. Welcome to the Tidyverse. *J Open Source Softw* 2019;4(43):1686.
- [23] INSEE. Tableaux de l'économie française [Internet]. [cited 2021 Feb 19]. Available from: <https://www.insee.fr/fr/statistiques/4277596?sommaire=4318291>
- [24] Annane D, Federici L, Chagnon JL, Diehl JL, Dreyfuss D, Guiot P, et al. Intensive care units, the Achilles heel of France in the COVID-19 battle. *Lancet Reg Health - Eur* 2021;2:100046.
- [25] Pilkington H, Feuillet T, Rican S, de Bouillè JG, Bouchaud O, Cailhol J, et al. Spatial determinants of excess all-cause mortality during the first wave of the COVID-19 epidemic in France. *BMC Public Health* 2021;21(1):2157.
- [26] French government. Système d'information pour le suivi des victimes d'attentats et de situations sanitaires exceptionnelles. [cited 2021 Apr 19]. Available from: <https://esante.gouv.fr/projets-nationaux/si-suivi-des-victimes-dattentats-et-de-situations-sanitaires>
- [27] Souris M, Gonzalez JP. COVID-19: spatial analysis of hospital case-fatality rate in France. *PLOS ONE* 2020;15(12):e0243606.
- [28] Sanchez MA, Vuagnat A, Grimaud O, Leray E, Philippe JM, Lescure FX, et al. Impact of ICU transfers on the mortality rate of patients with COVID-19: insights from comprehensive national database in France. *Ann Intensive Care* 2021;11(1):151.
- [29] Ohana M, Muller J, Severac F, Billault P, Behr M, Oberlin M, et al. Temporal variations in the diagnostic performance of chest CT for Covid-19 depending on disease prevalence: Experience from North-Eastern France. *Eur J Radiol* 2021;134 [cited 2021 Jun 16] Available from: [https://www.ejradiology.com/article/S0720-048X\(20\)30615-X/abstract](https://www.ejradiology.com/article/S0720-048X(20)30615-X/abstract).
- [30] Islam N, Ebrahimzadeh S, Salameh JP, Kazi S, Fabiano N, Treanor L, et al. Thoracic imaging tests for the diagnosis of COVID-19. *Cochrane Database Syst Rev* 2021;3:CD013639.
- [31] Lantelme P, Couray Targe S, Metral P, Bochaton T, Ranc S, Le Bourhis Zaimi M, et al. Worrying decrease in hospital admissions for myocardial infarction during the COVID-19 pandemic. *Arch Cardiovasc Dis* 2020;113(6):443–7.
- [32] Anne-Sophie Mariet, Maurice Giroud, Eric Benzenine, Jonathan Cottenet, Adrien Roussot, Serge Aho-Glélé Ludwig, et al. Hospitalizations for stroke in France during the COVID-19 pandemic before, during, and after the national lockdown. *Stroke*. 2021;52(4):1362–9.
- [33] Jollant F, Roussot A, Corruble E, Chauvet-Gelinier JC, Falissard B, Mikaeloff Y, et al. Hospitalization for self-harm during the early months of the COVID-19 pandemic in France: a nationwide retrospective observational cohort study. *Lancet Reg Health - Eur* 2021;6 [cited 2021 Jul 5] Available from: [https://www.thelancet.com/journals/lanep/article/PIIS2666-7762\(21\)00079-X/abstract](https://www.thelancet.com/journals/lanep/article/PIIS2666-7762(21)00079-X/abstract).
- [34] Piroth L, Cottenet J, Mariet AS, Bonniaud P, Blot M, Tubert-Bitter P, et al. Comparison of the characteristics, morbidity, and mortality of COVID-19 and seasonal influenza: a nationwide, population-based retrospective cohort study. *Lancet Respir Med* 2021;9(3):251–9.
- [35] Guillon A, Laurent E, Duclos A, Godillon L, Dequin PF, Agrinier N, et al. Case fatality inequalities of critically ill COVID-19 patients according to patient-, hospital- and region-related factors: a French nationwide study. *Ann Intensive Care* 2021;11(1):127.
- [36] Risser C, Tran Ba Loc P, Binder-Foucard F, Fabacher T, Lefèvre H, Sauvage C, et al. COVID-19 Impact on stroke admissions during France's first epidemic peak: an exhaustive, nationwide, observational study. *Cerebrovasc Dis* 2022:1–7.
- [37] Johns Hopkins University. COVID-19 Data Repository by the Center for Systems Science and Engineering (CSSE). 2021 [cited 2021 Mar 12]. Available from: <https://github.com/CSSEGISandData/COVID-19>
- [38] WHO. Emergency use ICD codes for COVID-19 disease outbreak. 2021; [cited 2021 Feb 19]. Available from: <https://www.who.int/standards/classifications/classification-of-diseases/emergency-use-icd-codes-for-covid-19-disease-outbreak>
- [39] Richardson S, Hirsch JS, Narasimhan M, Crawford JM, McGinn T, Davidson KW, et al. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City Area. *JAMA* 2020;323(20):2052.