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Impact of care reorganisation during COVID-19 waves on non-COVID-19 inpatients in a Swiss hospital: a retrospective cohort study

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Summary

STUDY AIMS: The COVID-19 pandemic required healthcare systems to reorganise around patient surges. Previous evidence associated these reorganisations with worse clinical outcomes for non-COVID-19 patients, to varying degrees. This exploratory study aimed to quantify the effects of successive COVID-19 waves on mortality, length of stay and transfers to intermediate and intensive care units among non-COVID-19 patients by comparing COVID-19 and non-COVID-19 periods in a Swiss hospital.

METHODS: This retrospective monocentric cohort study extracted electronic health data of patients hospitalised in a Swiss tertiary hospital from 1 January 2019 to 1 March 2023, whose primary discharge diagnosis was non-COVID-19, excluding patients from psychiatry and women-mother-child departments. Patients were then classified into COVID-19 wave periods based on the weekly average number of COVID admissions. Multivariable regressions were performed to compare in-hospital mortality, transfer rates to intermediate and intensive care units, and length of stay, adjusting for sex, age, insurance class, region of residence, level of care, Charlson comorbidity index, hospital department and main diagnosis.

RESULTS: A total of 22,972 non-COVID-19 patients hospitalised during three COVID-19 waves were included and compared to 51,252 pre-COVID-19 patients, 46,753 patients in the inter-wave period and 39,844 post-COVID-19 patients. Compared to the pre-COVID-19 period, adjusted in-hospital mortality among non-COVID-19 patients increased significantly during all COVID-19 waves, peaking in the first wave (OR: 1.27, 95% CI: 1.07–1.51), and decreased during inter-wave periods (OR: 0.91, 95% CI: 0.85–0.97). Transfers to intermediate care units increased throughout the COVID-19 period and normalised post-COVID-19, whereas transfers to intensive care units decreased significantly from the second wave onwards. Compared to the pre-COVID-19 period, length of stay did not differ during the first wave but was shorter in subsequent periods.

CONCLUSIONS: Worse outcomes among non-COVID-19 patients during COVID-19 waves highlight the need for protocols that ensure continuity and quality of care during future healthcare crises.

Introduction

The COVID-19 pandemic exerted immense pressure on healthcare systems worldwide, compelling countries to reorganise care at both national and hospital levels [1]. Responses varied across Europe, ranging from Sweden's strategy emphasising herd immunity [2, 3] to France's stringent lockdowns and implementation of COVID-19 passes to limit public access primarily to immune individuals [4, 5]. At the hospital level, many countries reduced elective surgeries and non-urgent care, reallocating resources to manage the surge of COVID-19 patients in acute care units [6]. Additionally, fear of COVID-19 infection among the general population may have led patients to delay or avoid seeking medical care, thereby further increasing barriers to healthcare access [7, 8].

Since the onset of the COVID-19 pandemic, numerous authors have raised concerns that both individual and systemic barriers may have compromised the quality of care for non-COVID patients during and after the pandemic waves [9, 10]. With rising human activity and the ongoing effects of climate change, the frequency of epidemics and pandemics is expected to increase [11, 12]. Understanding how the management of epidemic waves has affected non-COVID care is essential to building resilience in healthcare systems.

During the first COVID-19 wave, Switzerland recorded a relative excess mortality of 8.5% [13]. This figure may not be solely attributable to COVID-19-related deaths but also to factors such as delays in surgery [14], intensive care triage [15], patients avoiding care [16] and delays in treatment for non-COVID conditions [17].

This article aims to explore how COVID-19 waves and hospital reorganisation affected the care of non-COVID-19 patients by analysing excess mortality, transfer rates to intermediate and intensive care units and length of stay at Geneva University Hospital during the first three waves of the COVID-19 pandemic. These parameters were compared to the inter-wave periods as well as pre- and post-pandemic years.

Methods

In this retrospective cohort study, we analysed Electronic Health Record (EHR) data from all non-COVID-19 inpatients of Geneva University Hospital (HUG) from 1 January 2019 to 1 March 2023.

Setting

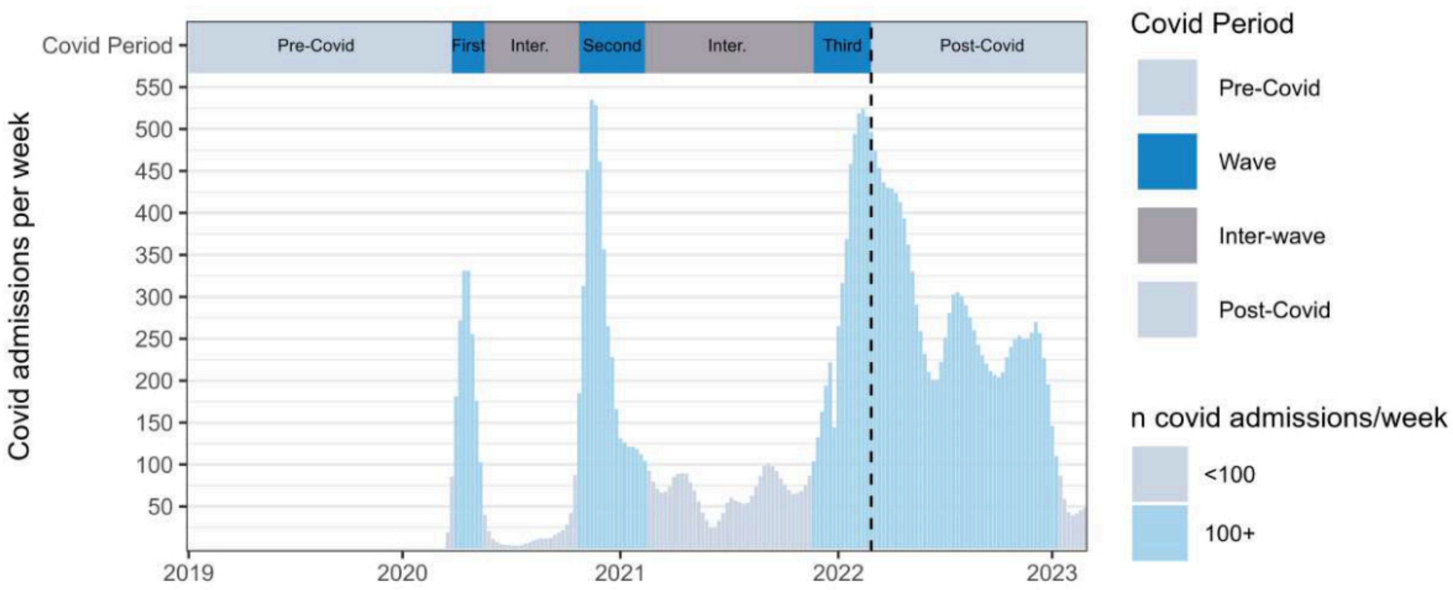
HUG is a tertiary university hospital located in Geneva, Switzerland. Although the Canton of Geneva has a population of about 530,000, HUG serves as the reference university hospital for the wider Greater Geneva cross-border region, amounting to roughly 1.5 million inhabitants and daily commuters. It manages around 60,000 inpatient stays and 1.2 million outpatient visits annually. Although data from other care centres were, initially, to be included in the study protocol, robust data could not be obtained for this analysis.

Exposure

At HUG, the first COVID-19 cases were admitted in February 2020. By March, the hospital had established dedicated acute, intermediate and intensive care units to manage the growing influx of COVID-19 patients. Significant structural changes were implemented during the pandemic: the number of beds was increased, elective surgeries were cancelled to repurpose surgical units for COVID patients, and additional intensive and intermediate care beds were created [18, 19]. Non-COVID cases were partially redirected to other regional secondary care facilities including a private secondary hospital and several private clinics in the canton that temporarily admitted non-severe patients with public insurance. Furthermore, many physicians, particularly from surgical departments or newly certified practitioners, were reassigned to COVID care.

Given that these changes were introduced and lifted incrementally, defining exact COVID-19 periods is challenging. For this study, we considered the hospital to be in "COVID mode" whenever the number of inpatients with a main diagnosis of COVID-19 exceeded 100 patients per week, representing 5 average units of 20 patients fully dedicated to COVID cases. To account for the high variability in weekly admissions, we computed a 4-week moving average of cases per week and based the definition of waves on this criterion. On 10 March 2022, despite a still-high absolute number of COVID-19 inpatients, HUG's pandemic management committee held its final meeting and officially declared the hospital to have returned to pre-crisis operations. This decision was based on a steady decrease in new COVID-19 admissions and a reduced proportion of severe cases. These changes also enabled the resumption of non-emergent surgeries. This date was therefore used as the end of the last COVID-19 wave at HUG (figure 1).

Figure 1: COVID-19 wave determination. COVID-19 wave periods were determined as ≥100 patients per week hospitalised with COVID-19 as a main ICD-10 diagnosis. Pre- and post-COVID-19 periods were defined as the 1-year period before and after the COVID-19 period. The end of the third COVID-19 wave was defined as the date at which Geneva University Hospital's internal committee for pandemic management held its last meeting and declared the institution out of the crisis. It is represented by the dotted vertical line on the graph.

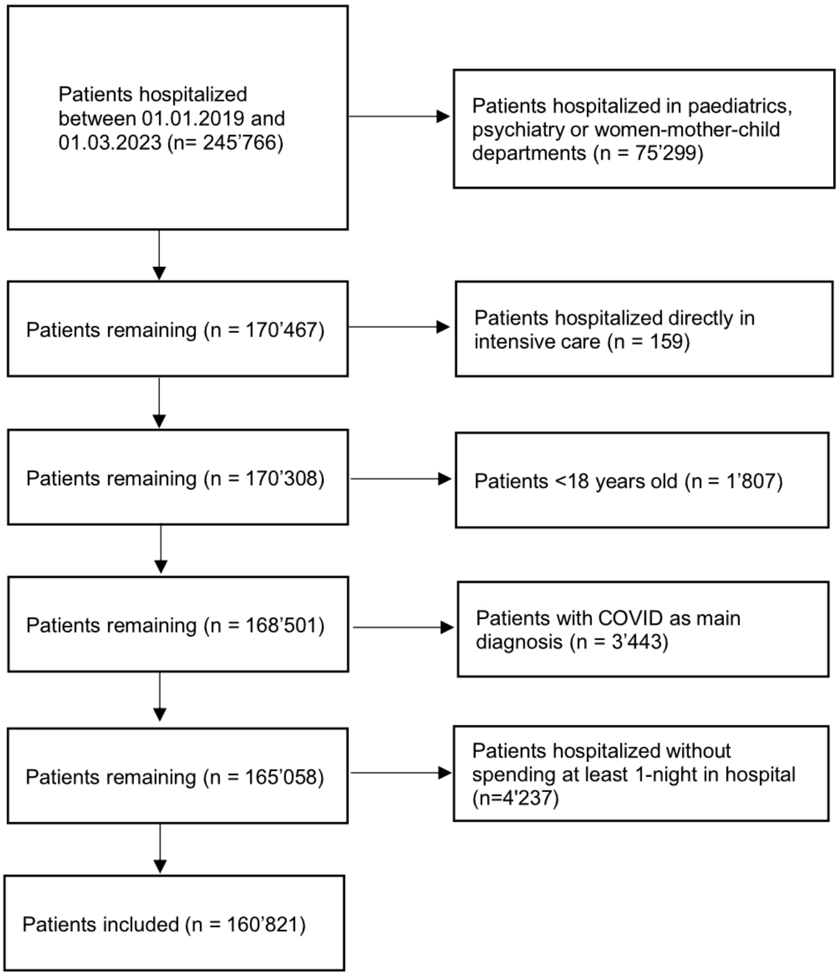


This classification identified three COVID-19 waves interspersed with two inter-wave periods (figure 2). Pre- and post-COVID-19 periods were defined as the 1-year period before the first wave and the 1-year period following the last wave. Patients were classified into the following COVID-19 phases:

1. Pre-COVID-19 period (01/JAN/2019 – 29/MAR/2020);
2. First COVID-19 wave (30/MAR/2020 – 17/MAY/2020);
3. First inter-wave period (18/MAY/2020 – 25/OCT/2020);
4. Second COVID-19 wave (26/OCT/2020 – 21/FEB/2021);
5. Second inter-wave period (22/FEB/2021 – 28/NOV/2021);
6. Third COVID-19 wave (29/NOV/2021 – 10/MAR/2022);
7. Post-COVID-19 period (11/MAR/2022 – 01/MAR/2023).

To ensure the reliability of this classification, wave characteristics, including the number of COVID-19 and non-COVID-19 patients per week, were computed and compared before further analysis.

Figure 2: Patient inclusion chart.



Outcomes

Four clinically relevant outcomes were assessed across the three COVID-19 waves, the inter-wave periods and the pre- and post-COVID-19 periods: in-hospital mortality, rate of transfer to intermediate and intensive care units, and lengths of stay. These outcomes were chosen for their potential to capture disruptions in care quality during and after the pandemic.

Population and data extraction

Anonymised data were extracted from the hospital's Electronic Health Record (EHR) using the admission date as the index date. Each hospitalisation was treated as an individual event without considering potential readmission of the same patients. Hospitalisations were defined as patients aged over 18 staying at least one night at the hospital outside the emergency care department. Exclusion criteria included hospitalisations directly to the intensive care unit – whether a transfer from another hospital or an ICU admission directly from the emergency room – and hospitalisation to the Psychiatry department or the Woman-Mother-Child department. These departments were excluded because our chosen outcomes – mortality, transfers to ICU or IMCU, length of stay – are not appropriate indicators of care quality in obstetric or psychiatric settings, where clinical trajectories and risks differ substantially from those of general medical and surgical patients. Mortality was defined using death dates that are automatically updated into the EHR for patients living in Geneva. Transfers to intensive or intermediate care units were defined by a stay in one of the intensive or intermediate care units of the hospital. Non-COVID patients were defined based on their main diagnosis at discharge, meaning that patients with a positive COVID-19 test were counted as non-COVID patients if their main diagnosis at discharge was not SARS-CoV-2 infection. We considered excluding all patients with a positive test but on verification this led to a loss of over 50% of patients during the peak of some waves including many patients that likely had asymptomatic or paucisymptomatic infections (table S1 in the appendix).

Statistical analysis

Analyses were conducted in R version 4.4.2 using the *comorbidity* library [20]. Unadjusted differences were initially visualised using means and 95% confidence intervals (95% CI) for length of stay, and proportions with exact 95% CIs for in-hospital mortality and for transfers to intermediate and intensive care units. Patient characteristics were compared using the Kruskal–Wallis test for non-parametric quantitative variables (age and Charlson score) and Fisher's exact tests for all the qualitative variables. Multivariable analyses were then conducted, employing a generalised linear model with a gamma regression and a log link for length of stay and logistic regressions for the remaining outcomes. COVID-19 periods were compared using the pre-COVID period as a reference, adjusting for demographic and hospitalisation variables to account for potential confounders.

Demographic variables included sex, age, region of residence (Geneva, other Swiss region, outside Switzerland) and insurance status (basic vs private).

Hospitalisation variables included frequent internal medicine diagnoses identified by the main ICD-10 diagnosis code (Stroke, Chronic obstructive pulmonary disease [COPD], Pulmonary embolism, Heart failure, Pneumonia, Sepsis, Myocardial infarction and other diagnoses), level of care (acute vs rehabilitation), Charlson Comorbidity Index approximated using the R *comorbidity* package on the ICD diagnosis list and hospital department (surgery vs medicine). The diagnosis categories were selected because they represent common internal medicine conditions and because most COVID-19-related organisational changes occurred within this department. The level of care variable distinguishes between acute hospitalisations and rehabilitation stays, the latter characterised by lower physician- and nurse-to-patient ratios and greater involvement of allied health professionals such as physiotherapists and dietitians. As we used routinely collected electronic health data, there were no missing data. No additional data cleaning procedures were performed, and all values were included as recorded in the source database.

Ethical approval and role of the funding source

This study was approved by the Geneva ethics committee (CCER-2020-01017) which waived the need to obtain informed consent, due to the retrospective nature of the study. This study was performed in accordance with relevant local regulations and followed the STROBE guidelines [21]. It was supported by a research grant attributed by a private hospital research grant called the Sennart Fund, which had no role in designing the protocol, or collecting or interpreting data.

Results

There were 245,766 unique admissions to HUG over the study period. After removing admissions to the paediatric, psychiatry and women-mother-child departments, patients hospitalised directly in intensive care units, patients aged below 18 years and admissions without at least one overnight stay, there were 160,821 non-COVID-19 admissions included in the study (figure 2). Of these, 22,972 were admitted during the three COVID-19 waves, 51,252 during the pre-COVID-19 period, 46,753 during the inter-wave periods and 39,844 during the post-COVID period (table 1). Overall, during the COVID-19 waves, non-COVID-19 patients were older, more likely to reside within the hospital region and much less likely to be admitted to the surgery department. During the first wave specifically, non-COVID-19 patients were more often women, less likely to have private insurance and less frequently admitted to acute care units. The main diagnosis also saw significant variations during the first wave with an increase in the proportion of patients with a main diagnosis of stroke, pulmonary embolism or myocardial infarction.

Table 1: Characteristics of COVID-19 waves and patients.

		Pre-COVID-19	Wave 1	Wave 2	Wave 3	Inter-wave	Post-COVID-19	p-value
Hospital occupation variables								
Non-COVID admissions		51,252	2837	9833	10,302	46,753	39,844	
Non-COVID patients/week		790.3	405.3	578.4	707.0	742.0	783.4	
COVID admissions		433	410	937	486	913	264	
COVID admissions/week*		6.7	58.6	55.1	33.3	14.5	5.2	
Demographic variables								
Non-COVID admissions		51,252	2837	9833	10,302	46,753	39,844	
Women, n (%)		25,112 (49.0%)	1433 (50.5%)	4798 (48.8%)	5049 (49.0%)	23,088 (49.4%)	19,725 (49.5%)	0.353
Age, median [IQR]		70.0 [53.0–82.0]	72.0 [55.0–83.0]	71.0 [54.0–83.0]	71.0 [54.0–83.0]	68.0 [51.0–81.0]	69.0 [52.0–82.0]	<0.001
Residence, n (%)	Geneva	45,190 (88.2%)	2560 (90.2%)	8832 (89.8%)	9102 (88.4%)	41,163 (88.0%)	34,800 (87.3%)	<0.001
	Other Swiss Canton	2990 (5.8%)	149 (5.3%)	544 (5.5%)	593 (5.8%)	2872 (6.1%)	2350 (5.9%)	
	Non-Swiss	3072 (6.0%)	128 (4.5%)	457 (4.6%)	607 (5.9%)	2718 (5.8%)	2694 (6.8%)	
Private insurance, n (%)		5814 (11.3%)	251 (8.8%)	1090 (11.1%)	1287 (12.5%)	5903 (12.6%)	5217 (13.1%)	<0.001
Hospitalisation variables								
Main diagnosis, n (%)	Stroke	1421 (2.8%)	109 (3.8%)	356 (3.6%)	278 (2.7%)	1333 (2.9%)	908 (2.3%)	<0.001
	COPD	718 (1.4%)	30 (1.1%)	96 (1.0%)	119 (1.2%)	405 (0.9%)	373 (0.9%)	
	Pulmonary embolism	319 (0.6%)	42 (1.5%)	82 (0.8%)	76 (0.7%)	264 (0.6%)	201 (0.5%)	
	Heart failure	1894 (3.7%)	102 (3.6%)	345 (3.5%)	429 (4.2%)	1448 (3.1%)	1420 (3.6%)	
	Pneumonia	1776 (3.5%)	43 (1.5%)	140 (1.4%)	254 (2.5%)	646 (1.4%)	1049 (2.6%)	
	Sepsis	570 (1.1%)	46 (1.6%)	119 (1.2%)	102 (1.0%)	460 (1.0%)	383 (1.0%)	
	Myocardial infarction	871 (1.7%)	59 (2.1%)	165 (1.7%)	195 (1.9%)	768 (1.6%)	661 (1.7%)	
	Other	43,683 (85.2%)	2406 (84.8%)	8530 (86.7%)	8849 (85.9%)	41,429 (88.6%)	34,849 (87.5%)	
Acute stay, n (%)		42,826 (83.6%)	2251 (79.3%)	7984 (81.2%)	8437 (81.9%)	38,627 (82.6%)	33,927 (85.1%)	<0.001
Charlson Comorbidity Score, n (%)	0–3	46,099 (89.9%)	2469 (87.0%)	8850 (90.0%)	9180 (89.1%)	42,256 (90.4%)	35,929 (90.2%)	<0.001
	4–7	2278 (4.4%)	156 (5.5%)	477 (4.9%)	545 (5.3%)	2052 (4.4%)	1816 (4.6%)	
	8–11	2766 (5.4%)	199 (7.0%)	492 (5.0%)	553 (5.4%)	2379 (5.1%)	2047 (5.1%)	
	12+	109 (0.2%)	13 (0.5%)	14 (0.1%)	24 (0.2%)	66 (0.1%)	52 (0.1%)	
Surgery department, n (%)		8952 (17.5%)	206 (7.3%)	894 (9.1%)	1297 (12.6%)	8210 (17.6%)	7167 (18.0%)	<0.001

*The number of COVID-19 admissions per week is under 60 during the COVID-19 waves because those are the number of admissions divided by the number of weeks in order to allow comparisons between periods of different lengths. The COVID-19 periods were defined using >60 patients as a moving average over a 4-week period which explains these numbers being lower than 60.

Pre- and post-COVID-19 periods were comparable in terms of the number of non-COVID-19 patients per week. However, the COVID-19 waves varied substantially from one another. The first wave showed the sharpest reduction in admission of non-COVID-19 patients, with an almost 50% decrease, from a mean 790.3 patients per week pre-COVID-19 to 405.3. This wave also recorded the highest number of COVID cases, with an average of 58.6 hospital admissions per week for patients with a primary diagnosis of COVID-19. During the inter-wave periods, the number of non-COVID-19 cases returned to levels closer to those of pre- and post-COVID-19 periods, averaging 742.0 new cases per week.

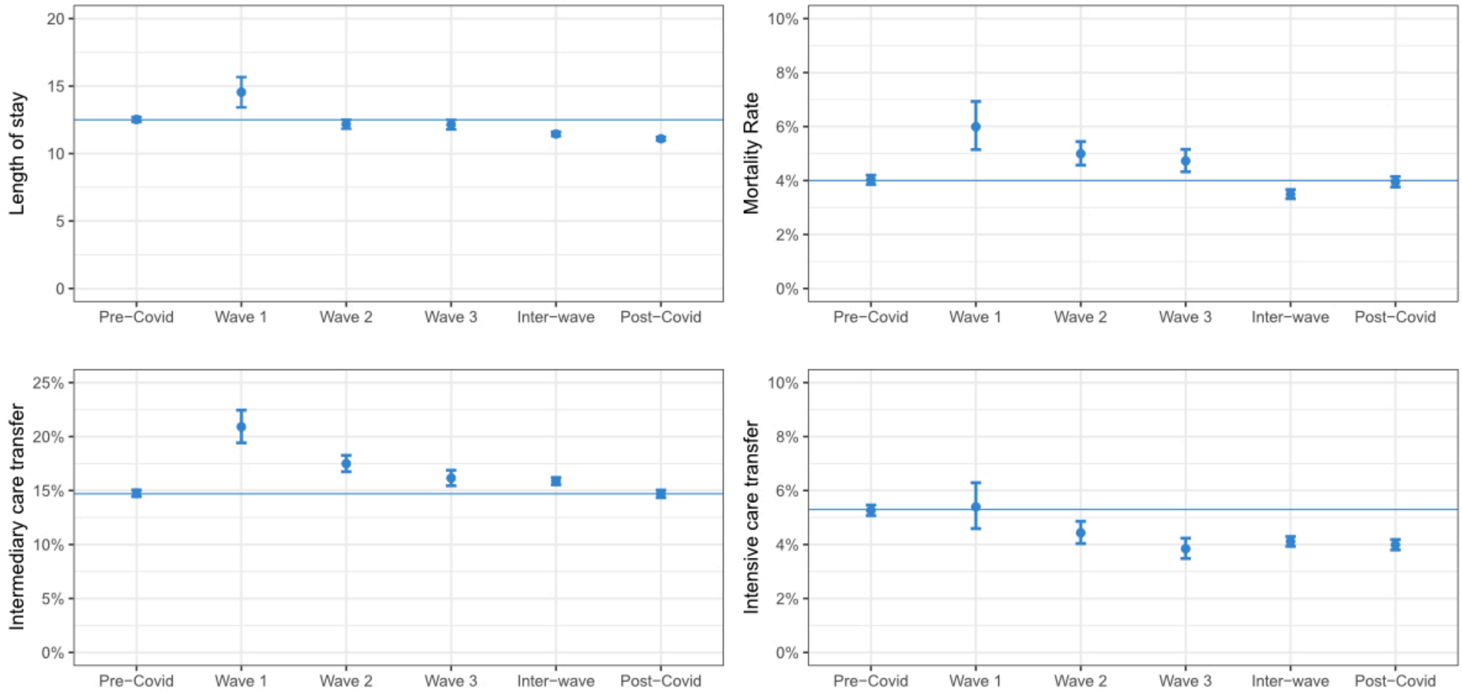
Unadjusted effects

All COVID-19 waves were associated with statistically significant increases in mortality among non-COVID-19 patients, with the first wave showing the highest spike at 6.0%, representing a 50% relative increase.

Intermediate care transfer rates were comparable pre- and post-COVID-19, averaging 14.7%. During all COVID-19 waves and inter-wave periods, these rates increased significantly, peaking at 20.9% in the first wave. Intensive care transfer rates remained stable at around 5.3% during the pre-COVID-19 period and first COVID-19 wave. However, they declined substantially during subsequent waves, inter-wave periods and the post-COVID-19 period, reaching a nadir of 3.8% during the third wave.

Length of stay (LOS) of non-COVID-19 patients increased sharply during the first COVID-19 wave, with a mean increase of 2.03 days and a median increase of 0.7 days compared to the pre-COVID-19 period. LOS gradually declined across subsequent waves and into the post-COVID-19 period. In-hospital mortality remained stable at approximately 4.0% before and after the pandemic (figure 3 and table S2 in the appendix).

Figure 3: Variations in length of stay, mortality rate and transfers to intermediate and intensive care units during COVID-19 periods. Pre-COVID rates are extended as a blue line to display the expected rates for each phase.



Multivariable analysis

In-hospital mortality

The adjusted model revealed a significant increase of in-hospital mortality during all the COVID-19 waves, with the sharpest rise observed during the first wave (OR: 1.27; 95% CI: 1.07–1.51) (table 2). Interestingly, there was also a statistically significant decrease in mortality during the inter-wave periods (OR: 0.91; 95% CI: 0.85–0.97).

Table 2: Multivariable logistic regression on in-hospital mortality rate and intermediate care transfer rate.

		In-hospital mortality			Intermediate care transfer		
		Odds ratio	**95% CI**	**p-value**	**Odds ratio**	**95% CI**	**p-value**
COVID-19 period							
Pre-COVID-19		*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
Wave 1		1.27	[1.07–1.51]	0.007	1.47	[1.32–1.62]	<0.001
Wave 2		1.18	[1.06–1.32]	0.002	1.16	[1.09–1.24]	<0.001
Wave 3		1.12	[1.01–1.25]	0.035	1.09	[1.02–1.16]	0.010
Inter-wave		0.91	[0.85–0.97]	0.006	1.11	[1.07–1.15]	<0.001
Post-COVID-19		0.99	[0.92–1.06]	0.741	1.00	[0.96–1.04]	0.929
Demographic variables							
Men		1.21	[1.15–1.28]	<0.001	1.14	[1.11–1.17]	<0.001
Age	18–34	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
	35–54	3.19	[2.35–4.34]	<0.001	1.44	[1.34–1.54]	<0.001
	55–74	7.43	[5.53–9.99]	<0.001	1.85	[1.73–1.97]	<0.001
	75+	15.70	[11.72–21.05]	<0.001	1.64	[1.53–1.75]	<0.001
Origin	Geneva	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
	Other Swiss	0.62	[0.52–0.75]	<0.001	1.12	[1.05–1.19]	<0.001
	Non-Swiss	1.02	[0.91–1.16]	0.709	1.26	[1.19–1.34]	<0.001
Insurance	Common	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
	Private	0.62	[0.57–0.67]	<0.001	1.43	[1.37–1.49]	<0.001
Hospitalisation variables							
Main diagnosis	Other*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
	Stroke	1.37	[1.20–1.56]	<0.001	17.13	[15.93–18.43]	<0.001
	COPD	1.05	[0.84–1.32]	0.644	0.94	[0.82–1.07]	0.339
	Pulmonary embolism	0.90	[0.67–1.22]	0.504	2.52	[2.20–2.90]	<0.001
	Heart failure	1.11	[0.99–1.24]	0.075	1.07	[1.00–1.16]	0.058
	Pneumonia	0.90	[0.77–1.04]	0.162	0.56	[0.50–0.62]	<0.001
	Sepsis	4.21	[3.70–4.80]	<0.001	4.21	[3.81–4.66]	<0.001
	Myocardial infarction	1.33	[1.11–1.60]	0.002	15.01	[13.73–16.41]	<0.001
Acute stay		3.34	[3.02–3.68]	<0.001	5.77	[5.40–6.17]	<0.001
Charlson	0–3	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
	4–7	2.54	[2.32–2.78]	<0.001	2.41	[2.27–2.55]	<0.001
	8–11	8.69	[8.12–9.29]	<0.001	1.28	[1.20–1.36]	<0.001
	12+	21.34	[16.47–27.64]	<0.001	2.60	[2.00–3.37]	<0.001
Department	Medicine	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
	Surgery	0.08	[0.07–0.10]	<0.001	0.47	[0.45–0.50]	<0.001

* “Other” main diagnoses are all those other than the seven prespecified.

Higher age categories, male sex (OR: 1.21; 95% CI: 1.15–1.28) and higher Charlson severity index were associated with higher in-hospital mortality. In contrast, private insurance was associated with reduced mortality (OR: 0.62; 95% CI: 0.57–0.67).

Transfer to intensive or intermediate care

Intermediate care transfer rates increased during all COVID-19 waves and inter-wave periods, returning to pre-COVID-19 values in the post-COVID-19 period (table 2). The largest increase was observed during the first wave (OR: 1.47; 95% CI: 1.32–1.62). In contrast, intensive care transfer rates were comparable to pre-COVID-19 levels (table 3). However, subsequent waves, inter-wave periods and the post-COVID periods showed significantly lower intensive care transfer rates, with the third wave recording the sharpest decrease in transfer rate (OR: 0.70; 95% CI: 0.62–0.78). For both intermediate and intensive care, transfers were more likely in patients with private insurance (intermediate care, OR: 1.43, 95% CI: 1.37– 1.49; intensive care, OR: 1.11; 95% CI: 1.04–1.19).

Table 3: Multivariable logistic regressions on transfers to intensive care units and gamma regression for length of stay.

		Intensive care transfer			Length of stay		
		Odds ratio	95% CI	p-value	exp(coef)	95% CI	p-value
COVID-19 period							
Pre-COVID-19		*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
Wave 1		0.97	[0.82–1.16]	0.746	1.05	[0.99–1.10]	0.099
Wave 2		0.80	[0.72–0.89]	<0.001	0.95	[0.92–0.98]	0.002
Wave 3		0.70	[0.62–0.78]	<0.001	0.97	[0.94–1.00]	0.034
Inter-wave		0.76	[0.71–0.81]	<0.001	0.94	[0.93–0.96]	<0.001
Post-COVID-19		0.74	[0.69–0.79]	<0.001	0.94	[0.92–0.95]	<0.001
Demographic variables							
Men		1.31	[1.25–1.38]	<0.001	1.01	[0.99–1.02]	0.448
Age	18–34	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
	35–54	1.37	[1.24–1.51]	<0.001	1.31	[1.27–1.35]	<0.001
	55–74	1.55	[1.41–1.71]	<0.001	1.65	[1.60–1.69]	<0.001
	75+	0.61	[0.55–0.68]	<0.001	2.04	[1.98–2.09]	<0.001
Origin	Geneva	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
	Other Swiss	1.81	[1.66–1.97]	<0.001	1.11	[1.08–1.14]	<0.001
	Non-Swiss	1.90	[1.76–2.05]	<0.001	0.92	[0.89–0.95]	<0.001
Insurance	Common	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
	Private	1.11	[1.04–1.19]	0.003	1.01	[0.99–1.03]	0.371
Hospitalisation variables							
Main diagnosis*	Other	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
	Stroke	2.62	[2.35–2.92]	<0.001	1.02	[0.98–1.06]	0.369
	COPD	2.07	[1.74–2.47]	<0.001	1.01	[0.94–1.08]	0.802
	Pulmonary embolism	1.78	[1.39–2.28]	<0.001	0.93	[0.85–1.02]	0.134
	Heart failure	0.89	[0.76–1.03]	0.119	1.20	[1.16–1.25]	<0.001
	Pneumonia	0.53	[0.43–0.66]	<0.001	0.95	[0.90–0.99]	0.016
	Sepsis	6.75	[5.97–7.63]	<0.001	1.52	[1.42–1.63]	<0.001
	Myocardial infarction	3.47	[3.11–3.87]	<0.001	0.85	[0.80–0.89]	<0.001
Acute stay		6.99	[6.02–8.11]	<0.001	0.37	[0.36–0.37]	<0.001
Charlson		1.12	[1.11–1.133]	<0.001	1.10	[1.09–1.10]	<0.001
	0–3	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
	4–7	2.86	[2.63–3.11]	<0.001	1.72	[1.66–1.78]	<0.001
	8–11	1.13	[1.02–1.25]	0.017	1.63	[1.58–1.69]	<0.001
	12+	1.80	[1.18–2.76]	0.007	2.55	[2.15–3.01]	<0.001
Department	Medicine	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
	Surgery	0.53	[0.49–0.58]	<0.001	0.63	[0.61–0.64]	<0.001

* "Other" main diagnoses are all those other than the seven prespecified. Length of stay was modelled using a gamma regression and is reported as the exponentiated coefficient.

Length of stay

While the observed increase in LOS during the first COVID-19 wave was no longer significant in the adjusted model, the observed reduction post-COVID-19 remained significant, though small (table 3).

Discussion

In this observational study of more than 150,000 patients with a non-COVID-19 main diagnosis (i.e. non-COVID patients) in a large tertiary hospital, important changes in patient-relevant clinical outcomes were observed over the 4-year study period.

Mortality

An increased in-hospital mortality among non-COVID-19 patients, particularly prominent during the first COVID-19 wave, was observed and remained significant after adjustment. Several factors may have contributed to this finding. First, the high pressure on hospital capacity during the COVID-19 waves may have led to the selective admission of more-severe cases. Although our multivariable model accounted for key prognostic variables, residual confounding cannot be ruled out. Additionally, the cancellation of surgeries and patients delaying care due to fear of contamination likely resulted in more-severe conditions upon admission for non-COVID patients [14], contributing to higher in-hospital mortality [17]. This interpretation is supported by the increase in the proportion of life-threatening diagnoses like pulmonary embolism and myocardial infarction and the increase in the Charlson Comorbidity Index during the first wave, when patients with a score of 8 or higher rose from 5.6% to 7.5% compared to the pre-COVID-19 period (table 1). Other factors, such as reduced referrals to the hospital by general practitioners [16, 22] or stricter triage in the emergency care unit, may have further delayed treatment and exacerbated outcomes [23].

In most hospitals, drastic reorganisations were rapidly implemented to manage the influx of COVID-19 patients. For instance, intermediate care units, postoperative care facilities and operating theatres were repurposed as ICUs [18], while additional intermediate care unit beds were opened [19]. Emergency care shifts were extended from 10 to 12 hours, and many healthcare professionals were reassigned to roles outside their primary field of expertise.

Interestingly, the extent of these disruptions varied across the three COVID-19 waves, which may explain the observed differences in excess mortality. The first wave, during which non-COVID-19 activities were most heavily restricted, displayed the highest excess mortality compared to the pre-COVID-19 period. In contrast, the second and third waves imposed fewer restrictions on non-COVID-19 admissions and coincided with lower excess mortality. These findings suggest that maintaining some level of normal care delivery during pandemic surges may help mitigate excess mortality among all patients. Selective management of less-severe non-COVID patients outside the hospital may have led to residual confounding by patient severity, possibly contributing partially to the observed excess mortality, but this hypothesis remains speculative and hardly quantifiable.

Beyond these structural changes, healthcare workers experienced intense psychological pressure, resulting in increased anxiety and a documented need for psychological support that was difficult to access [24, 25]. Prolonged working hours [26, 27], lack of expertise due to being assigned to unfamiliar specialties and psychological distress [28] are all factors associated with higher rates of medical errors, potentially compromising the quality of care.

Lastly, increased mortality may have been partially attributed to nosocomial COVID-19 infections. Since non-COVID-19 cases were defined by the absence of COVID-19 as a primary diagnosis, some excess mortality could be linked to healthcare-associated COVID-19 infections in otherwise non-COVID-19 patients. However, while this factor may explain part of the observed mortality, the incidence of COVID-19 infections within the hospital was 9.2 per 100 hospitalisations, which is comparable to the population rate in Geneva [29], suggesting that healthcare-associated infections alone are unlikely to fully account for the increase in mortality.

During the inter-wave period, the mortality rate was significantly reduced (OR: 0.91, 95% CI: 0.85–0.97) compared to pre-COVID-19 levels. This temporary reduction in mortality, following periods of increased mortality, may be explained by a mortality displacement or harvesting effect. This phenomenon, well-documented in other crises such as heat waves [30] and influenza epidemics [31], occurs when the most vulnerable individuals succumb during the crisis, leading to a subsequent, compensatory period of reduced mortality. Our findings are consistent with previous research that observed a similar post-crisis mortality pattern following the first COVID-19 wave in northern Italy [32].

ICU and intermediate care transfer rates

ICU transfers of non-COVID-19 patients progressively decreased across subsequent waves, despite the admission of more-severe patients with higher mortality rates [17]. However, the demand for ICU beds increased due to both COVID-19 and non-COVID-19 patients requiring critical care. This pressure led to the development of a new triage algorithm, designed to allocate scarce ICU resources as equitably as possible [15, 33]. Although this algorithm, intended to limit ICU admissions in case of resource shortages, was not formally deployed at our hospital, its development might have improved the consistency and application of admission criteria. In parallel, the pandemic prompted the widespread adoption of high-flow ventilation [34] and the expansion of intermediate care units beds which led to the implementation of local triage procedures between intensive and intermediate care [19]. These measures likely contributed to the reduction of ICU transfers by providing effective alternatives to ICU admissions. The persistence of this reduction of ICU transfers beyond the pandemic suggests a structural reorganisation rather than a temporary crisis-driven measure. As this shift was not accompanied by increased mortality, it likely reflects more efficient triage of patients. Acute care teams may have gained greater confidence in managing selected cases outside the ICU and in identifying those most likely to benefit from intensive care. The expanded use of high-flow oxygen therapy and enhanced monitoring in intermediate care settings probably reinforced this transition towards a more selective and effective allocation of critical care resources.

Length of stay

Finally, an increase in length of stay was noted for non-COVID-19 patients during the first wave; however, this association disappeared after adjusting for patient and hospital characteristics. Two main reasons may explain this change.

Firstly, non-COVID patients during the first wave were generally older, a well-established risk factor for longer hospital stays [35]. Secondly, the hospital implemented a policy of cancelling all elective surgeries, which likely influenced the distribution of hospitalised patients. Overall, the decreasing trend in length of stay is aligned with previous studies indicating that efforts to reduce hospital LOS are effective [36, 37].

Important covariate effects

Interestingly, two covariates showed noteworthy associations with our outcomes: insurance status and advanced age.

First, privately insured patients were significantly less likely to die and more likely to be admitted to intermediate care units and ICUs. In Switzerland, mandatory basic health insurance covers most hospitalisation costs. However, individuals may purchase optional supplementary private insurance, which primarily offers accommodation benefits, such as private rooms, but may also promote faster access to treatments or free choice of surgeon [38]. Private insurance may serve as a proxy for higher socioeconomic status, which is known to be associated with lower in-hospital mortality [39]. Additionally, privately insured patients may be more proactive in seeking high levels of care and might be more likely to opt in for ICU admission when discussing advanced directives. However, this finding raises the possibility of preferential treatment for privately insured patients when assigning scarce intermediate care and ICU beds. While previous studies have generally found no effect or even a lower likelihood of ICU admission for privately insured patients [40, 41], ensuring equitable care remains a critical concern that warrants further investigation.

Second, patients aged 75 years and older were more likely to be admitted to intermediate care and to die, while being significantly less likely to be transferred to intensive care units. This finding aligns with recent studies showing that age is negatively associated with ICU admission rates, independently of comorbidity or frailty [42, 43]. Several mechanisms have been proposed, including limited ICU bed availability, physicians' prognostic considerations and patients' reduced preference for intensive care interventions [43, 44].

Both associations arise from analyses that were not specifically designed to explore these effects and should therefore be interpreted with caution and investigated further in dedicated studies [45].

Strengths and limitations

The main strength of this study is its large sample size, encompassing all patients admitted over a 4-year period and focusing on in-hospital outcomes that were fully documented. Methodological efforts were undertaken to reduce selection bias and remaining confounders by selecting COVID-19 periods based on an objective measure and by adjusting for hospital, patient and stay variables. There are also some limitations. First, the absence of standardised cause-of-death information in the electronic health record restricts our ability to differentiate between deaths caused by secondary COVID-19 infections and those resulting from the primary conditions for which the patients were admitted. Second, care unit reorganisation strategies varied between hospitals during the pandemic, and the monocentric design of the present study limits the generalisability of our findings. Reorganisation also occurred across waves, which provided within this study a unique opportunity to assess the impact of different organisation models on non-COVID-19 patient outcomes. The detailed description of our hospital's strategy offers sufficient context for other hospital management teams to assess the applicability of our findings to their setting. Third, the covariables included in the analysis were constrained by the available data, leaving room for residual confounding. In particular, the main diagnosis was categorised into seven typical medical diagnoses, with approximately 80% of patients classified under "Other". That said, our approach of comparing seven typical medical diagnoses versus all others was not intended to fully adjust for comorbidity, but rather to provide insight into whether the effects of the reorganisation differed across clinically relevant patient groups. Fourth, the definition of non-COVID-19 patients as patients without a primary diagnosis of COVID-19 may have excluded patients who were nevertheless hospitalised for this infection. However, this was necessary as patients during high waves almost all had a secondary diagnosis of COVID. Fifth, because repeat hospitalisations for the same patients could not be identified in the anonymised dataset, within-patient correlation could not be accounted for, which may lead to an underestimation of standard errors. Lastly, the observational nature of this study limits our ability to establish causal relationships between reorganisation efforts and the observed effects on patient outcomes.

Conclusion

This study evaluated the impact of successive COVID-19 waves and associated care reorganisation on non-COVID-19 patients' in-hospital mortality, transfers to intermediate and intensive care units and length of stay. Adjusted analysis of over 150,000 non-COVID-19 patients revealed that mortality and intermediate care transfers increased during all three COVID waves whereas intensive care transfers and length of stay consistently declined during and after the COVID period.

These opposite trends likely reflect both the structural reorganisation of care, such as expanded intermediate care capacity and stricter ICU admission criteria, and indirect effects of delayed presentation or altered clinical decision-making during periods of crisis.

As future epidemics are likely, policymakers, hospital management teams and clinicians should anticipate these systemic trade-offs and design preparedness plans that protect access and quality of care for all patients.

Data sharing statement

The anonymised dataset of this study is available from the corresponding author upon reasonable request. The analytical code is available in the appendix.

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Potential competing interests

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. No potential conflict of interest related to the content of this manuscript was disclosed.

References

1. Filip R , Gheorghita Puscaselu R , Anchidin-Norocel L , Dimian M , Savage WK . Global Challenges to Public Health Care Systems during the COVID-19 Pandemic: A Review of Pandemic Measures and Problems. J Pers Med. 2022 Aug;(8):1295. https://doi.org/10.3390/jpm12081295 36013244 2075-4426
2. Diderichsen F . How did Sweden Fail the Pandemic? Int J Health Serv. 2021 Oct;(4):417–22. https://doi.org/10.1177/0020731421994848 33635123 1541-4469
3. Hassan MS , Al Halbusi H , Razali A , Ariffin RN , Williams KA . The Swedish gamble: trust in the government and self-efficacy in the battle to combat COVID-19. Curr Psychol. 2022 Mar;(21):1–16. https://doi.org/10.1007/s12144-022-02947-w 35340688 1046-1310
4. Mongin D , Buclin CP , Cullati S , Courvoisier DS . COVID-19 Vaccination Rate under Different Political Incentive: A Counterfactual Trend Approach Using Nationwide Data. Vaccines (Basel). 2023 Jun;(7):1149. https://doi.org/10.3390/vaccines11071149 37514965 2076-393X
5. Antonini M , Eid MA , Falkenbach M , Rosenbluth ST , Prieto PA , Brammli-Greenberg S , et al. An analysis of the COVID-19 vaccination campaigns in France, Israel, Italy and Spain and their impact on health and economic outcomes. Health Policy Technol. 2022 Jun;(2):100594. https://doi.org/10.1016/j.hlpt.2021.100594 34976711 2211-8837
6. Mehta A , Awuah WA , Ng JC , Kundu M , Yarlagadda R , Sen M , et al. Elective surgeries during and after the COVID-19 pandemic: case burden and physician shortage concerns. Ann Med Surg (Lond). 2022 Sep;:104395. https://doi.org/10.1016/j.amsu.2022.104395 35999832 2049-0801
7. Menon LK , Richard V , de Mestral C , Baysson H , Wisniak A , Guessous I , et al.; Specchio-COVID19 Study Group . Forgoing healthcare during the COVID-19 pandemic in Geneva, Switzerland - A cross-sectional population-based study. Prev Med. 2022 Mar;:106987. https://doi.org/10.1016/j.ypmed.2022.106987 35150752 1096-0260
8. Anderson KE , McGinty EE , Presskreischer R , Barry CL . Reports of Forgone Medical Care Among US Adults During the Initial Phase of the COVID-19 Pandemic. JAMA Netw Open. 2021 Jan;(1):e2034882. https://doi.org/10.1001/jamanetworkopen.2020.34882 33475757 2574-3805
9. Tuczyńska M , Matthews-Kozanecka M , Baum E . Accessibility to Non-COVID Health Services in the World During the COVID-19 Pandemic: review [Review]. Front Public Health. 2021 Dec;:760795. https://doi.org/10.3389/fpubh.2021.760795 34976922 2296-2565
10. Barach P , Fisher SD , Adams MJ , Burstein GR , Brophy PD , Kuo DZ , et al. Disruption of healthcare: will the COVID pandemic worsen non-COVID outcomes and disease outbreaks? Prog Pediatr Cardiol. 2020 Dec;:101254. https://doi.org/10.1016/j.ppedcard.2020.101254 32837144 1058-9813
11. Meadows AJ , Stephenson N , Madhav NK , Oppenheim B . Historical trends demonstrate a pattern of increasingly frequent and severe spillover events of high-consequence zoonotic viruses. BMJ Glob Health. 2023 Nov;(11):e012026. https://doi.org/10.1136/bmjgh-2023-012026 37918874 2059-7908
12. Carlson CJ , Albery GF , Merow C , Trisos CH , Zipfel CM , Eskew EA , et al. Climate change increases cross-species viral transmission risk. Nature. 2022 Jul;(7919):555–62. https://doi.org/10.1038/s41586-022-04788-w 35483403 1476-4687
13. Staub K , Panczak R , Matthes KL , Floris J , Berlin C , Junker C , et al. Historically High Excess Mortality During the COVID-19 Pandemic in Switzerland, Sweden, and Spain. Ann Intern Med. 2022 Apr;(4):523–32. https://doi.org/10.7326/M21-3824 35099995 1539-3704
14. Rachamin Y , Meyer MR , Rosemann T , Grischott T . Impact of the COVID-19 Pandemic on Elective and Emergency Inpatient Procedure Volumes in Switzerland - A Retrospective Study Based on Insurance Claims Data. Int J Health Policy Manag. 2023;:6932. https://doi.org/10.34172/ijhpm.2022.6932 36243943 2322-5939

15. Vinay R , Baumann H , Biller-Andorno N . Ethics of ICU triage during COVID-19. Br Med Bull. 2021 Jun;(1):5–15. https://doi.org/10.1093/bmb/ldab009 34057458 1471-8391

16. Hautz WE , Sauter TC , Exadakytlos AK , Krummrey G , Schauber S , Müller M . Barriers to seeking emergency care during the COVID-19 pandemic may lead to higher morbidity and mortality - a retrospective study from a Swiss university hospital. Swiss Med Wkly. 2020 Aug;(3334):w20331. https://doi.org/10.4414/smw.2020.20331 32799308 1424-3997

17. Gasch-Illescas A , Calle-Serrano M , Vallejo-Vaz AJ , Praena-Fernández JM , Guerrero JA , Calderón EJ , et al. Impact of the first wave of the COVID-19 pandemic on non-COVID inpatient care in southern Spain. Sci Rep. 2023 Jan;(1):1634. https://doi.org/10.1038/s41598-023-28831-6 36717651 2045-2322

18. Primmaz S , Le Terrier C , Suh N , Ventura F , Boroli F , Bendjelid K , et al. Preparedness and Reorganization of Care for Coronavirus Disease 2019 Patients in a Swiss ICU: Characteristics and Outcomes of 129 Patients. Crit Care Explor. 2020 Jul;(8):e0173. https://doi.org/10.1097/CCE.0000000000000173 32766566 2639-8028

19. Grosgurin O , Leidi A , Farhoumand PD , Carballo S , Adler D , Reny JL , et al. Role of Intermediate Care Unit Admission and Noninvasive Respiratory Support during the COVID-19 Pandemic: A Retrospective Cohort Study. Respiration. 2021;(8):786–93. https://doi.org/10.1159/000516329 34023830 1423-0356

20. R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL . n.d.

21. Cuschieri S . The STROBE guidelines. Saudi J Anaesth. 2019 Apr;(5 Suppl 1):S31–4. https://doi.org/10.4103/sja.SJA_543_18 30930717 1658-354X

22. Zakeri MA , Dehghan M . The impact of the COVID-19 disease on the referral and admission of the non-COVID-19 patients. Int J Health Plann Manage. 2021 Jan;(1):209–11. https://doi.org/10.1002/hpm.3060 32841418 1099-1751

23. Peros G , Gronki F , Molitor N , Streit M , Sugimoto K , Karrer U , et al. Organizing a COVID-19 triage unit: a Swiss perspective. Emerg Microbes Infect. 2020 Dec;(1):1506–13. https://doi.org/10.1080/22221751.2020.1787107 32579076 2222-1751

24. Zara G , Settanni M , Zuffranieri M , Veggi S , Castelli L . The long psychological shadow of COVID-19 upon healthcare workers: A global concern for action. J Affect Disord. 2021 Nov;:220–6. https://doi.org/10.1016/j.jad.2021.07.056 34303300 1573-2517

25. Uccella L , Majno-Hurst P , Uccella S , et al. Psychological Impact of a Pandemic Widespread in Healthcare Workers: The Italian and Swiss Perspective Early After of CoVid-19 Outbrea 2020. https://doi.org/https://doi.org/10.21203/rs.3.rs-41724/v1

26. Landrigan CP , Rothschild JM , Cronin JW , Kaushal R , Burdick E , Katz JT , et al. Effect of reducing interns' work hours on serious medical errors in intensive care units. N Engl J Med. 2004 Oct;(18):1838–48. https://doi.org/10.1056/NEJMoa041406 15509817 1533-4406

27. Barger LK , Ayas NT , Cade BE , Cronin JW , Rosner B , Speizer FE , et al. Impact of extended-duration shifts on medical errors, adverse events, and attentional failures. PLoS Med. 2006 Dec;(12):e487. https://doi.org/10.1371/journal.pmed.0030487 17194188 1549-1676

28. Tawfik DS , Profit J , Morgenthaler TI , Satele DV , Sinsky CA , Dyrbye LN , et al. Physician Burnout, Well-being, and Work Unit Safety Grades in Relationship to Reported Medical Errors. Mayo Clin Proc. 2018 Nov;(11):1571–80. https://doi.org/10.1016/j.mayocp.2018.05.014 30001832 1942-5546

29. Mongin D , Catho G , Iten A , et al. Incidence of healthcare-associated coronavirus disease 2019 (COVID-19) in the state of Geneva. Infect Control Hosp Epidemiol. 2021;: https://doi.org/10.1017/ice.2021.453 34689854 0899-823X

30. Luy M , Di Giulio P , Di Lego V , Lazarevič P , Sauerberg M . Life Expectancy: Frequently Used, but Hardly Understood. Gerontology. 2020;(1):95–104. https://doi.org/10.1159/000500955 31390630 1423-0003

31. Lytras T , Pantavou K , Mouratidou E , Tsiodras S . Mortality attributable to seasonal influenza in Greece, 2013 to 2017: variation by type/subtype and age, and a possible harvesting effect. Euro Surveill. 2019 Apr;(14):1800118. https://doi.org/10.2807/1560-7917.ES.2019.24.14.1800118 30968823 1560-7917

32. Alicandro G , Remuzzi G , La Vecchia C . Italy's first wave of the COVID-19 pandemic has ended: no excess mortality in May, 2020. Lancet. 2020 Sep;(10253):e27–8. https://doi.org/10.1016/S0140-6736(20)31865-1 32891216 1474-547X

33. Joebges S , Biller-Andorno N . Ethics guidelines on COVID-19 triage-an emerging international consensus. Crit Care. 2020 May;(1):201. https://doi.org/10.1186/s13054-020-02927-1 32375855 1466-609X

34. Raoof S , Nava S , Carpati C , Hill NS . High-Flow, Noninvasive Ventilation and Awake (Non-intubation) Proning in Patients With Coronavirus Disease 2019 With Respiratory Failure. Chest. 2020 Nov;(5):1992–2002. https://doi.org/10.1016/j.chest.2020.07.013 32681847 1931-3543

35. Jentzsch T , Seifert B , Neuhaus V , Moos RM . Predictors for shorter and longer length of hospital stay outliers: a retrospective case-control study of 8247 patients at a university hospital trauma department. Swiss Med Wkly. 2018 Aug;(3334):w14650. https://doi.org/10.4414/smw.2018.14650 30141523 1424-3997

36. Boes S , Napierala C . Assessment of the introduction of DRG-based reimbursement in Switzerland: evidence on the short-term effects on length of stay compliance in university hospitals. Health Policy. 2021 Jun;(6):739–50. https://doi.org/10.1016/j.healthpol.2021.01.010 33910763 1872-6054

37. Edelmann L , Hempel M , Podsiadlo N , Schweizer N , Tong C , Galvain T , et al. Reduced Length of Stay Following Patient Pathway Optimization for Primary Hip and Knee Arthroplasty at a Swiss Hospital. Clinicoecon Outcomes Res. 2022;:105–17. https://doi.org/10.2147/CEOR.S348475 1178-6981

38. Altwicker-Hámori S , Stucki M . Factors associated with the choice of supplementary hospital insurance in Switzerland - an analysis of the Swiss Health Survey. BMC Health Serv Res. 2023 Mar;(1):264. https://doi.org/10.1186/s12913-023-09221-0 36927575 1472-6963

39. McHenry RD , Moultrie CE , Quasim T , Mackay DF , Pell JP . Association Between Socioeconomic Status and Outcomes in Critical Care: A Systematic Review and Meta-Analysis. Crit Care Med. 2023 Mar;(3):347–56. https://doi.org/10.1097/CCM.0000000000005765 36728845 1530-0293

40. Bein T , Hackner K , Zou T , Schultes S , Bösch T , Schlitt HJ , et al. Socioeconomic status, severity of disease and level of family members' care in adult surgical intensive care patients: the prospective ECSSTASI study. Intensive Care Med. 2012 Apr;(4):612–9. https://doi.org/10.1007/s00134-012-2463-x 22273749 1432-1238

41. Ruger JP , Richter CJ , Lewis LM . Association between insurance status and admission rate for patients evaluated in the emergency department. Acad Emerg Med. 2003 Nov;(11):1285–8. https://doi.org/10.1197/S1069-6563(03)00500-1 14597506 1069-6563

42. Turnbull AE , Lau BM , Ruhl AP , Mendez-Tellez PA , Shanholtz CB , Needham DM . Age and decisions to limit life support for patients with acute lung injury: a prospective cohort study. Crit Care. 2014 May;(3):R107. https://doi.org/10.1186/cc13890 24886945 1466-609X

43. Foley C , Bloomer M , Hutchinson AM . Factors that influence intensive care admission decisions for older people: A systematic review. Aust Crit Care. 2023 Mar;(2):274–84. https://doi.org/10.1016/j.aucc.2021.12.006 35144889 1036-7314

44. Akinosoglou K , Schinas G , Almyroudi MP , Gogos C , Dimopoulos G . The impact of age on intensive care. Ageing Res Rev. 2023 Feb;:101832. https://doi.org/10.1016/j.arr.2022.101832 36565961 1872-9649

45. Westreich D , Greenland S . The table 2 fallacy: presenting and interpreting confounder and modifier coefficients. Am J Epidemiol. 2013 Feb;(4):292–8. https://doi.org/10.1093/aje/kws412 23371353 1476-6256

Impact of Care Reorganization during COVID-19 Waves on non-COVID Inpatients in a Swiss Hospital: a retrospective cohort study

Supplementary materials

Table S1 Number of patients with COVID as a secondary diagnosis

	Pre-COVID	Wave 1	Wave 2	Wave 3	Inter-wave	Post-COVID	P-value
n admissions	51’252	2’837	9’833	10’302	46’753	39’844	
COVID as secondary diagnosis n (%)	306 (0.6)	211 (7.4)	1114 (11.3)	1’158 (11.2)	1’097 (2.3)	2’608 (6.5)	<0.001

Table S2 Effect of the COVID Phase on Patients' outcomes

	Pre-COVID	Wave 1	Wave 2	Wave 3	Inter-wave	Post-COVID	P-value
n	51’252	2’837	9’833	10’302	46’753	39’844	
Length of Stay							
median [IQR]	7.05 [2.73, 14.87]	7.92 [3.03, 17.68]	7.45 [3.06, 15.18]	7.53 [3.10, 14.95]	6.91 [2.53, 14.10]	6.91 [2.65, 14.20]	<0.001
mean (SD)	12.52 (22.13)	14.55 (30.52)	12.17 (16.84)	12.14 (18.32)	11.45 (17.99)	11.10 (14.18)	<0.001
Transfers							
Intensive care transfer (%)	2’698 (5.3)	153 (5.4)	436 (4.4)	396 (3.8)	1’922 (4.1)	1’589 (4.0)	<0.001
Intermediary care transfer (%)	7’557 (14.7)	593 (20.9)	1’720 (17.5)	1’664 (16.2)	7’420 (15.9)	5’853 (14.7)	<0.001
Mortality							
In-hospital death (%)	2’062 (4.0)	170 (6.0)	491 (5.0)	487 (4.7)	1’634 (3.5)	1’573 (3.9)	<0.001

Analyctical code

```
Libraries ####

library(ggplot2)

library(lubridate)

library(scales)

library(patchwork)

library(data.table)

library(xlsx)

library(readxl)

library(openxlsx)

library(stringr)

library(ComplexUpset)

library(UpSetR)

library(plyr)

library(reshape2)

library(tableone)

library(comorbidity)

library(patchwork)

library(Hmisc)

library(performance)

library(emmeans)

library(broom.mixed)

#### Unadjusted Graphs ####

#LOS

los_hug.p<-ggplot(data=HUG_Vague.dt,aes(x=vague,y=mean))+

  geom_point(aes(colour="Mean"),size=2)+


geom_errorbar(aes(ymin=mean_ci95_lower,ymax=mean_ci95_upper,colour="Mean"),width=.1,line
width=1)+

  geom_rect(aes(xmin=-Inf,xmax=Inf, ymin=12.33336, ymax = 12.71655), alpha=0.05, fill="dark
blue")+

  coord_cartesian(ylim=c(10,17))+
```



```
  labs(y="Length of stay in days",x="",colour="")+
  scale_colour_manual(values = colors_los)+
  theme_bw(base_size = 18)+
  theme(legend.position="none")

#Mortality
colors_morta <- c("In-hospital Mortality" = "#3686cf", "90-days Mortality" = "#3686cf")
mortality_hug.p<-ggplot(data=Hug_vague_dcd.dt,aes(x=vague,y=dcd_percent))+
  geom_point(aes(colour="In-hospital Mortality"),size=2)+
  geom_errorbar(aes(ymin=dcd_lower,ymax=dcd_upper,colour="In-hospital
Mortality"),width=.1,linewidth=1)+
  #geom_hline(aes(yintercept=0.04),colour="#3686cf")+
  #geom_point(aes(y=dcd_90_percent,colour="90-days Mortality"),size=3)+
  #geom_errorbar(aes(ymin=dcd_90_lower,ymax=dcd_90_upper,colour="90-days
Mortality"),width=.1,linewidth=1.2)+
  #geom_hline(aes(yintercept=0.088),colour="")+
  geom_rect(aes(xmin=-Inf,xmax=Inf, ymin=0.03854767, ymax = 0.04196981), alpha=0.05, fill="dark
blue")+
  scale_y_continuous(labels = scales::percent,breaks = c(0,0.02,0.04,0.06,0.08,0.10,0.12))+
  labs(y="Mortality rate",x="",colour="")+
  scale_colour_manual(values = colors_morta)+
  theme_bw(base_size = 18)+
  coord_cartesian(ylim=c(0.00,0.08))+ theme(legend.position="none")+
  theme(axis.text.x = element_blank())

#ICU/IMC
colors_soins <- c("Intensive Care Unit"= "#3686cf", "Intermediary Care Unit" = "#3686cf")
soins_hug.p<-ggplot(data=Hug_vague_soins.dt,aes(x=vague,y=si_percent))+
  geom_point(aes(colour="Intensive Care Unit"),size=3)+
  geom_errorbar(aes(ymin=si_lower,ymax=si_upper,colour="Intensive Care
Unit"),width=.1,linewidth=1.2)+
  geom_hline(aes(yintercept=0.147),colour="#3686cf")+
```

```
 geom_point(aes(y=sint_percent,colour="Intermediary Care Unit"),size=3)+
 geom_errorbar(aes(ymin=sint_lower,ymax=sint_upper,colour="Intermediary Care Unit"),width=.1,linewidth=1.2)+
 geom_hline(aes(yintercept=0.053),colour="#a5ccf0")+
 labs(y="Transfer Rate",x="",colour="")+
 scale_y_continuous(labels = scales::percent)+
 scale_colour_manual(values = colors_soins)+
 theme_bw(base_size = 19)



si_hug.p<-ggplot(data=Hug_vague_soins.dt,aes(x=vague,y=si_percent))+
 geom_point(aes(colour="Intensive Care Unit"),size=2)+
 geom_errorbar(aes(ymin=si_lower,ymax=si_upper,colour="Intensive Care Unit"),width=.1,linewidth=1)+
 #geom_hline(aes(yintercept=0.147),colour="#3686cf")+
 #geom_point(aes(y=sint_percent,colour="Intermediary Care Unit"),size=3)+
 #geom_errorbar(aes(ymin=sint_lower,ymax=sint_upper,colour="Intermediary Care Unit"),width=.1,linewidth=1.2)+
 #geom_hline(aes(yintercept=0.053),colour="#3686cf")+
 geom_rect(aes(xmin=-Inf,xmax=Inf, ymin=0.05072410, ymax = 0.05461046), alpha=0.05, fill="dark blue")+
 labs(y="Intensive care transfer",x="",colour="")+
 scale_y_continuous(labels = scales::percent,breaks = c(0,0.02,0.04,0.06,0.08,0.10,0.12))+
 scale_colour_manual(values = colors_soins)+
 theme_bw(base_size = 19)+
 coord_cartesian(ylim=c(0,0.08))+ theme(legend.position="none")
sint_hug.p<-ggplot(data=Hug_vague_soins.dt,aes(x=vague,y=si_percent))+
 #geom_point(aes(colour="Intensive Care Unit"),size=3)+
 #geom_errorbar(aes(ymin=si_lower,ymax=si_upper,colour="Intensive Care Unit"),width=.1,linewidth=1.2)+
 #geom_hline(aes(yintercept=0.147),colour="#3686cf")+
 geom_rect(aes(xmin=-Inf,xmax=Inf, ymin=0.1443886, ymax = 0.1505472), alpha=0.05, fill="dark blue")+
```

```
 geom_point(aes(y=sint_percent,colour="Intermediary Care Unit"),size=2)+

 geom_errorbar(aes(ymin=sint_lower,ymax=sint_upper,colour="Intermediary Care
Unit"),width=.1,linewidth=1)+

 #geom_hline(aes(yintercept=0.053),colour="#a5ccf0")+

 labs(y="Intermediate care transfer",x="",colour="")+

 scale_y_continuous(labels = scales::percent)+

 scale_colour_manual(values = colors_soins)+

 theme_bw(base_size = 19)+

 coord_cartesian(ylim=c(0,0.25))+

 theme(legend.position="none",

     axis.text.x = element_blank())


##Patchwor all figures

graph_2.p<-mortality_hug.p+sint_hug.p+si_hug.p+los_hug.p


#### Multivariable analysise ####

##LOS

adjusted_LOS.lm<-
glm(LOS_admin~HUG_Vague+Sexe+age_cat+canton+diag_1_cat_nona+care_level_all+Classe_cat+CC
I_cat+chir_med,data=fusion,family=Gamma(link=log))

summary(adjusted_LOS.lm)


#Mortality


adjusted_death.lm<-glm(death~


HUG_Vague+Sexe+age_cat+canton+diag_1_cat_nona+care_level_all+Classe_cat+CCI_cat+chir_med,

               data=fusion,

               family=binomial)

summary(adjusted_death.lm)


#Intermediary care
```

```
adjusted_interm.lm<-glm(SINT~

HUG_Vague+Sexe+age_cat+canton+diag_1_cat_nona+care_level_all+Classe_cat+CCI_cat+chir_med,
                    data=fusion,
                    family=binomial)
summary(adjusted_interm.lm)

#Intensive care
adjusted_intens.lm<-glm(SI~

HUG_Vague+Sexe+age_cat+canton+diag_1_cat_nona+care_level_all+Classe_cat+CCI_cat+chir_med,
                    data=fusion,
                    family=binomial)
summary(adjusted_intens.lm)

#### Tables creation ####
format_digit <- function(nbr,
                     digitsafterdot = 2){
  return(formatC(nbr,
              format = "f",
              digits = digitsafterdot)
  )
}



# function to write the p value
writepvalue <- function(pvalue) {
  if (is.na(pvalue)) {result <- NA} else {
    if(pvalue < 0.001) {
      result <- "<0.001"
    } else if (pvalue <0.01) {
      result <- formatC( pvalue ,
```

```
                    format = "f",
                    digits = 3)
   }
   else {
    (result <- formatC( pvalue ,
                    format = "f",
                    digits = 2) )
    i = 1
    while(result == 0.05) {
     result <- formatC( pvalue ,
                    format = "f",
                    digits = 2 + i)
     i = i + 1
    }}
   return(result)
  }
}

writepvalue2 <- function(pvalue) {
  if (is.na(pvalue)) {
   result <- NA
  } else {
   if (pvalue < 0.001) {
    result <- "<0.001"
   } else {
    result <- formatC(pvalue, format = "f", digits = 3)
   }
  }
  return(result)
}
# vectorized version
```

```
writepvalue_vec <- Vectorize(writepvalue)

writepvalue2_vec <- Vectorize(writepvalue2)



sign = function(val){

  ifelse(val %between% c(0.01,0.05),"*",

         ifelse(val %between% c(0.001,0.01),"**",

                ifelse(val < 0.001,"***","")

         )

  )

}




format_res = function(estimate,std.error,p.value){


  low <- estimate - 1.96*std.error

  high <- estimate + 1.96*std.error

  nlow = 2

  nhigh = 2

  while(as.numeric(format_digit(estimate)) == as.numeric(format_digit(low,digitsafterdot  = nlow))){

    nlow = nlow+1

  }

  while(as.numeric(format_digit(estimate)) == as.numeric(format_digit(high,digitsafterdot  = nhigh))){

    nhigh = nhigh+1

  }


  paste0(format_digit(exp(estimate)),sign(p.value)," [",format_digit(exp(low),nlow),", 
",format_digit(exp(high),nhigh),"]")

}
```

```
format_res_vec <- Vectorize(format_res)

output_format = function(fit){
  tmp <- broom.mixed::tidy(fit) %>% setDT()
  tmp <- tmp[!is.na(tmp$std.error),]
  tmp[,res := format_res_vec(estimate,std.error = std.error,p.value = p.value)]
  tmp[,split_res:=strsplit(res, " \\[|, |\\]")]
  tmp[,OR:=sapply(split_res, function(x) x[1])]
  tmp[,CI95:=sapply(split_res, function(x) paste0("[", x[2], ", ", x[3], "]"))]
  tmp[,p := writepvalue2_vec(p.value)]
  tmp[,.(term,OR,CI95,p)]

}

los_multivar <- output_format(adjusted_LOS.lm)
death_multivar <- output_format(adjusted_death.lm)
interm_multivar<-output_format(adjusted_interm.lm)
intens_multivar<-output_format(adjusted_intens.lm)
#Table 2
multivar_table2<-cbind(death_multivar,interm_multivar)
#Table 3
multivar_table3<-cbind(intens_multivar,los_multivar)
```