BMJ Open

Sex-specific Impact of the first COVID-19 Lockdown on Age Structure and Case Acuity at Admission in a Patient Population in southwestern Germany: a retrospective comparative Study in Neuroradiology

Sebastian R Reder , Natalie Herrlich, Nils F Grauhan, Ahmed E Othman, Matthias Müller-Eschner, Carolin Brockmann, Marc A Brockmann

To cite: Reder SR, Herrlich N, Grauhan NF, *et al*. Sex-specific Impact of the first COVID-19 Lockdown on Age Structure and Case Acuity at Admission in a Patient Population in southwestern Germany: a retrospective comparative Study in Neuroradiology. *BMJ Open* 2024;**14**:e079625. doi:10.1136/bmjopen-2023-079625

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (https://doi.org/10.1136/bmjopen-2023-079625).

Received 07 September 2023
Accepted 26 February 2024

Dpt. of Neuroradiology, University Medical Center of the Johannes Gutenberg University, Mainz, Germany

Correspondence to
Dr Sebastian R Reder;
sebastianreder91@gmail.com

ABSTRACT

Objectives A hard lockdown was presumed to lead to delayed diagnosis and treatment of serious diseases, resulting in higher acuity at admission. This should be elaborated based on the estimated acuity of the cases, changes in findings during hospitalisation, age structure and biological sex.

Design Retrospective monocentric cross-sectional study.

Setting German Neuroradiology Department at a .

Participants In 2019, n=1158 patients were admitted in contrast to n=884 during the first hard lockdown in 2020 (11th–13th week).

Main outcome measures Three radiologists evaluated the initial case acuity, classified them into three groups (not acute, subacute and acute), and evaluated if there was a relevant clinical deterioration. The data analysis was conducted using non-parametric methods and multivariate regression analysis.

Results A 24% decrease in the number of examinations from 2019 to 2020 (p=0.025) was revealed. In women, the case acuity increased by 21% during the lockdown period (p=0.002). A 30% decrease in acute cases in men was observable (in women 5% decrease). Not acute cases decreased in both women and men (47%; 24%), while the subacute cases remained stable in men (0%) and decreased in women (28%). Regression analysis revealed the higher the age, the higher the acuity (p<0.001 in both sexes), particularly among women admitted during the lockdown period (p=0.006).

Conclusion The lockdown led to a decrease in neuroradiological consultations, with delays in seeking medical care. In women, the number of most severe cases remained stable, whereas the mean case acuity and age increased. This could be due to greater pandemic-related anxiety among women, however, with severe symptoms they were seeking for medical help. In contrast in men, the absolute number of most severe cases decreased, whereas the mean acuity and age remained nearly unaffected. This could be attributable to a reduced willingness to seek for medical consultation.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study employed a comparative and retrospective analysis, using a substantial sample size (n=2042) and considering various parameters for evaluation, ensuring a comprehensive assessment of the impact of the COVID-19 lockdown on acuity of neuroradiological cases (March 2019 vs 2020).

⇒ The study primarily focused on the early weeks of the COVID-19 pandemic, and there is no exploration of intrapandemic situations (eg, 2021/2022), which could provide additional insights into the long-term impact on neuroradiological cases.

⇒ The assessment of case acuity and deterioration in findings had been conducted by experienced radiologists with ≥4 years of experience, and any uncertainties are resolved through consensus readings, enhancing the reliability of the study's findings.

⇒ While efforts are made to standardise cases, external factors influencing patient behaviours, such as fear of infection, public health messaging, or changes in healthcare-seeking attitudes, might not be fully accounted for in the analysis.

INTRODUCTION

During the outbreak of the COVID-19 virus and its declaration as a pandemic by the WHO in 2020, governments worldwide implemented nationwide lockdowns to protect their citizens.[1] In Germany, restrictions were imposed between 16 March 2020 and 23 March 2020: the timeline of events from 16 March 2020 to 22 March 2020, reflects the swift and decisive measures taken in response to the escalating COVID-19 pandemic in Germany.[2] The nationwide closure of non-essential businesses on 16 Marc, with exceptions for vital services, marked the beginning of significant restrictions.[2] Subsequent days

saw the acknowledgement of the high-risk situation by the Robert Koch Institute, leading to a global travel warning and financial support for repatriation efforts.[2] The closure of EU borders on 18 March further emphasised the severity of the situation, and Chancellor Angela Merkel's impactful video message underscored the gravity of the challenge facing Germany[2]: 'As Germany faced its most significant challenge since World War II, these measures aimed at protecting public health and managing the unprecedented situation.[2]' The closure of restaurants on 21 March and the implementation of a nationwide contact ban on 22 March, although stopping short of a strict lockdown, demonstrated a commitment to limiting social interactions and slowing the spread of the virus.[2]

Despite the known and unknown socioeconomic limitations that these interventions would have on the population, the German government decided to postpone planned treatments, if medically justifiable, in order to preserve capacities.[3] During this period, several neuroradiological departments in Germany and other countries reported a temporary decrease in diagnostic and therapeutic case numbers.[4 5] Pfaff *et al*[4] found that fear of infection was a primary reason for the decrease in medical consultations,[4] which was confirmed by several other international multicentre studies.[6–9] This effect was consistent for elective examinations, however, also for examinations associated with acute cases.[9–12] According to the findings of Willms *et al*[13], two factors significantly contributed to the decrease in severe cases during the COVID-19 lockdown: (1) more stringent selection criteria for medical treatment and (2) patients delaying their medical consultations.[13] Likewise, individuals with chronic illnesses, including those undergoing diagnosis and active treatment for cancer, observed a reduced likelihood of seeking medical consultations during the COVID-19 lockdown in 2020.[14–16] Numerous studies conducted during the onset of the pandemic have documented a significant increase in anxiety and depressive disorders both during and after the COVID-19 lockdown.[17–21] The overall concern about contracting the virus and the adherence to social distancing guidelines are presumed to have contributed to the decrease in the number of cases across various disciplines,[5 15 22] resulting in a higher fatality rate due to delayed hospitalisation.[23 24] Some studies indicated that a general reluctance to seek medical advice among men within the pandemic led to a decrease in severe cases and to higher mortality rates while dying at home.[25 26]

The aim of this study was to determine whether there were significant differences between the period before and during the first COVID-19 lockdown, including factors such as the acuity of cases, a relevant deterioration in the further course of hospitalisation, as well as the technical modality used.

We hypothesised (1) a drop in patient numbers in 2020 and (2) an increase in incidence in severe and decrease in mild cases from 2019 to 2020.

MATERIALS AND METHODS

Patient involvement statement

In this retrospective study, patients were not actively engaged in the recruitment or execution of the study. Reporting results to study participants did not occur, as there was no immediate benefit for them; instead, the benefit lied in contributing to the broader understanding for the general population. Additionally, the burden of the intervention was not assessed by patients themselves, as this was a retrospective study without specific study-related burdens.

Centre of investigation, study population and selection criteria

The Department of Neuroradiology at the University Medical Centre Mainz is a hub of excellence, offering top-tier diagnostic, advisory and therapeutic services. Specialising in minimally invasive treatments for vascular disorders of the head and spinal cord, interventions for several conditions such as strokes, aneurysms, arteriovenous malformations and dural arteriovenous fistulas are performed. As the largest neuroradiological centre in Rhineland-Palatinate, it contributes around 200 stroke treatments annually, ensuring 24/7 stroke care. With 800 angiographies, 200 stroke treatments, 100 aneurysm treatments, 5000 MRI scans and 15 000 CT scans conducted annually, the department exemplifies a commitment to excellence and innovation in neuroradiology at the University Medical Centre Mainz. Furthermore, the University Medical Centre of the Johannes Gutenberg-University Mainz caters to 64 547 inpatient cases, attend to 283 964 outpatient cases, maintain a capacity of 1665 beds and employ 8698 dedicated professionals, providing specialised care to each patient.[27]

The department of neurosurgery has a total of 66 inpatient beds distributed across various units with its own neurosurgical intensive care unit with ten beds, as well as an intermediate care unit with four beds. Another distinctive aspect is the dedicated unit for early rehabilitation, comprising four beds.[28]

The neurology department, with a total of 42 beds, provides comprehensive neurological care. Its certified stroke unit, equipped with 12 beds, is complemented by 4 beds for intermediate care and 6 intensive care beds through collaboration with internal medicine and anesthesiology. Additionally, two beds are dedicated to continuous electroencephalogram (EEG) monitoring for potential surgical treatment indications in therapy-resistant epilepsies.[29]

All findings of the Department of Neuroradiology of the University Medical Centre Mainz within the 11th and 13th week of 2019 (1275 cases; 'prelockdown') were analysed retrospectively and compared with the same calendar weeks of 2020 (923 cases; 'lockdown'). All cases included in our analyses were those admitted during this period and received initial imaging through neuroradiology, followed by subsequent imaging to assess potential deterioration in the clinical course morphologically. For 2019, n=117 and for 2020 n=39 data sets were excluded due to

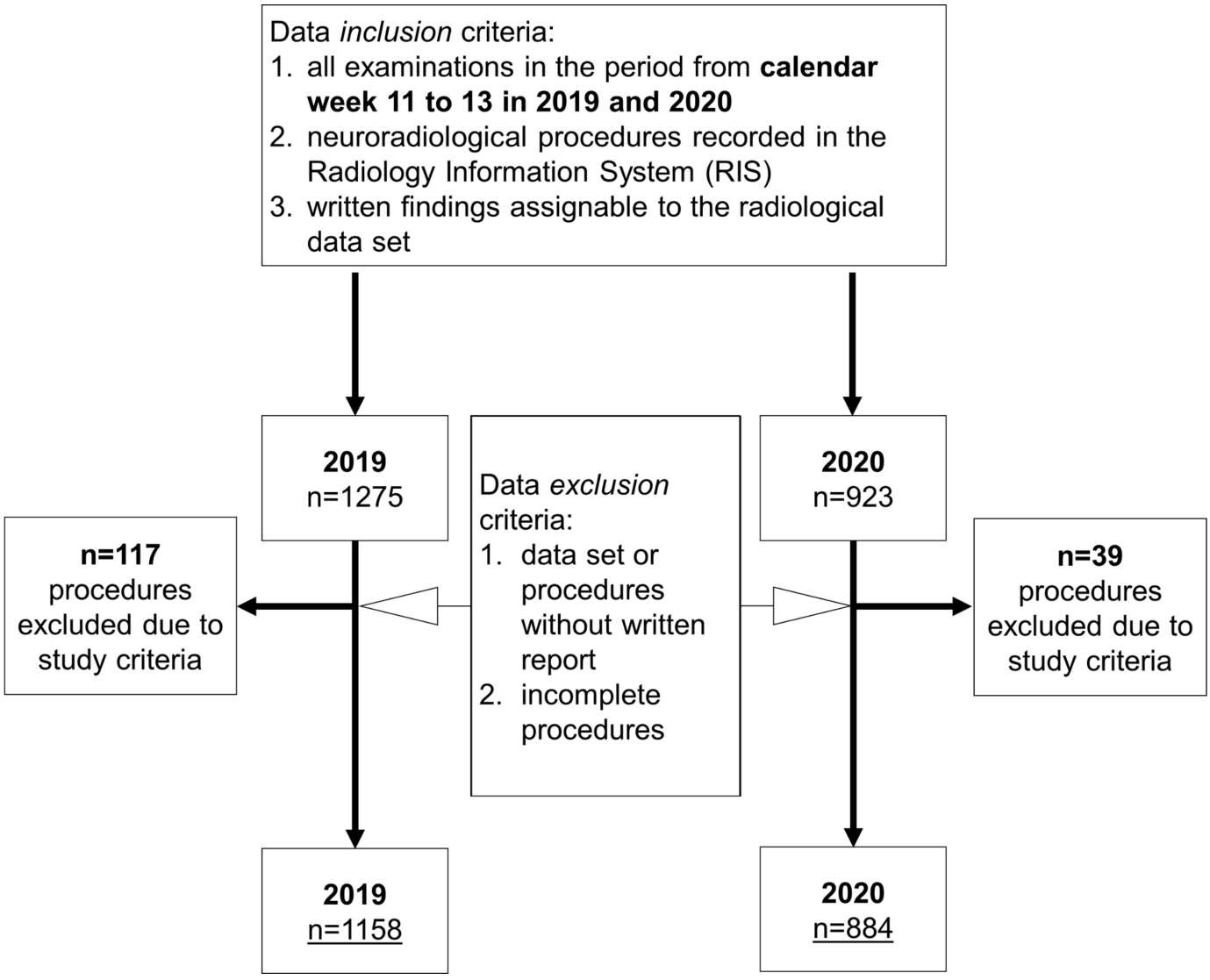

Figure 1 Flow chart of study-related inclusion criteria and population selection.

incomplete image acquisitions or uncertainly assignable written reports. Finally, n=1158 (2019) and n=884 (2020) data sets have been included (figure 1). As depicted in online supplemental figure 1A, relevant decline in case numbers was observed only in the year 2020, compared with the prepandemic (2017: n=1256; 2018: n=1237; 2019: n=1275) and intrapandemic years (2021: n=1295). The cases were randomised and equally distributed among the three radiologists by the same medical student.

Parameters

Several parameters were extracted from the radiolocal information system (RIS) considered for evaluation: patient age and gender, as well as the time of examination, technical modalities, the anatomic region of interest, the availability of previous images within the database and the referral institution (table 1). The technical modalities included the digital subtraction angiography, native CT, CT angiography (CTA), CT perfusion (CTP), MRI and X-ray, whereas CTA and CTP were classified as one category (CTA/CTP) due to their strong correlation to stroke diagnosis. The (anatomic) regions of interest consisted of head and neck, spinal cord, thorax and regions other than those mentioned ('others'). Referrer categories included the surgical and internal emergency department, as well as external hospitals/rescue services. Based on this information, three readers (radiologists) classified the acuity (A category) and, in the case of subsequent follow-up examinations, a relevant change in findings indicating deterioration (D category; online supplemental table 1). If the acuity of a case was unclear for a single reader, a consensus reading was conducted. Here, all three readers collaboratively decided on the case classification and its interpretation.

Case acuity (A category) and deterioration in findings in follow-up imaging (D category) were classified by radiologists with ≥4 years of experience from the Department of Neuroradiology at the University Medical Centre Mainz (online supplemental table 1) by using all available data from the RIS and written reports. The experience in evaluating

Table 1 Study population characteristics

Group	Subgroup		Prelockdown	Lockdown	Δ (%)	P value
Total	–		1158	884	-24	**0.025**
Sex	Female		565 (48.8%)	386 (43.7%)	-32	**0.025**
	Male		593 (51.2%)	498 (56.3%)	-16	
Age	Female		60.4±21.7	62±21.5	–	>0.05
	Male		61±20	61.3±19.5	–	
Case acuity (number)	A0		459 (39.6%)	293 (33.1%)	-36	**0.02** **F: 0.008** **M: 0.04**
		Female	239 (42.3%)	126 (32.6%)	-47	
		Male	220 (37.1)	167 (33.5%)	-24	
	A1		474 (40.9%)	411 (46.5%)	-13	
		Female	223 (39.5%)	160 (41.5%)	-28	
		Male	251 (42.3%)	251 (50.4%)	0	
	A2		177 (15.3%)	143 (16.2%)	-19	
		Female	77 (13.6%)	73 (18.9%)	-0.5	
		Male	100 (16.9%)	70 (14.1%)	-30	
	Missing		48 (4.1%)	37 (4.2%)	–	
Case acuity (mean/SD)	Female		A0.7±0.7	A0.85±0.73	–	**0.011**
	Male		A0.79±0.72	A0.8±0.67	–	>0.05
Case acuity (median/IQR)	Female		A1 (1)	A1 (1)	–	0.008
	Male		A1 (1)	A1 (1)	–	0.048
Relevant deterioration	No (D0)		700 (60.4%)	499 (56.4%)	-29	>0.05
	Yes (D1)		409 (35.3%)	348 (39.4%)	-15	
	Missing		49 (4.2%)	37 (4.2%)	–	
Region of interest	Head and neck		952 (82.2%)	751 (85%)	-21	**<0.001**
	Spinal cord		141 (12.2%)	107 (12.1%)	-24	
	Thorax		62 (5.4%)	22 (2.5%)	-64	
	Others		3 (0.3%)	3 (0.3%)	0	
Modality	DSA		60 (5.2%)	41 (4.6%)	-32	**0.018**
	Native CT		553 (47.8%)	435 (49.2%)	-21	
	CTA/CTP		141 (12.2%)	106 (12%)	-25	
	MRI		304 (26.3%)	266 (30.1%)	-13	
	X-ray		100 (8.6%)	36 (4.1%)	-64	
Referrer	Emergency Dpt. (surgical)		237 (20.5%)	210 (23.8%)	-11	**0.01**
	Emergency Dpt. (internal)		651 (56.2%)	440 (49.8%)	-32	
	Rescue service/external		219 (18.9%)	196 (22.2%)	-10	
	Missing		51 (4.4%)	38 (4.3%)	–	

Characteristics compared with the prelockdown (2019) and lockdown (2020) period in mean±SD or total number (and proportion in %) including the difference Δ (in ±%) from the prelockdown to the lockdown period. The bold numbers indicate significant values
CTA, CT angiography; CTP, CT perfusion; DSA, digital subtraction angiography.

neuroradiological imaging material for the three readers was as follows: reader 1=4 years, reader 2=7 years and reader 3 more than 10 years. Category A0 included, among others, symptom-free patients with oncological diseases during follow-up imaging and trauma patients without acute symptoms ('time to treatment within 72 hours'). Patients with mild to moderate radiculopathies and mild neurological deficits were placed in category A1 ('time to treatment between 24 and 48 hours'). Category A2 included patients with acute stroke, intracranial haemorrhage, the most severe pain or significant progression in a known disease, such as cauda equine syndrome ('time to treatment under 10 hours'). Patients' outcomes (or 'relevant deterioration during hospitalisation') were classified as D0 and D1. D0 described

no relevant changes in known clinical abnormalities (eg, control examinations according to guidelines or acute cephalgia), while D1 included any worsening in findings compared with the initial findings.

Statistics

All analyses were performed using the statistical software SPSS (V.28, IBM). First, the number of cases and their characteristics between the prelockdown period (2019) and the beginning of the lockdown period (2020) during the 11th until 13th week of March were compared. The parameters were scaled and handled as follows: period of time=nominal, age=metrically, biological sex=nominal, daytime=metrically, referrer=nominal, case acuity=ordinal, deterioration classification=ordinal, region of interest=nominal and modality=nominal.

Due to the absence of normally distributed values and the robustness of non-parametric test procedures, the Mann-Whitney U test was employed for the analyses of independent ordinal and metrically scaled variables. If there were more than two groups, the Kruskal-Wallis test was used. The difference between the median in the acuity was tested by using the Cramer-V test for nominal scaled variables (due to the use of one nominal scaled parameter: period of time). The differences between period-dependent nominal (and/or ordinal) scaled groups were analysed using the χ^2 test. Further, the influences of age, period of time (prelockdown vs lockdown) and relevant deterioration in further course of hospitalisation (D category) on the acuity of cases (A category) were analysed using multiple linear regression analysis. With a sample size of n=2042, a statistical power of 0.9, and a significance level of α=0.05, a determination coefficient of R^2=0.006 would be needed for a significant overall model with two predictors (R^2=0.007 with three predictors).[30] For re-evaluation, the results were confirmed using the Spearman test for ordinal parameters. The Kruskal-Wallis test was used to determine differences in the mean and SD of metrically scaled variables among groups.

For each of following significance values, we used a 95% CI with two-sided (and if available asymptotic) significance niveau. Considering multicollinearity, there were several significant correlations between groups and subgroups. However, there was no relevant (r<|0.8|) multicollinearity associated interaction.[1 31] Mediator analysis (by PROCESS-Macro from Hayes for SPSS) revealed no significant interactions.[32]

RESULTS

A significant decrease of 24% in overall case numbers from the prelockdown compared with the lockdown period was observable (n=1158 vs n=884; p=0.025; table 1). In women, the number of A0 and A1 cases significantly decreased by 47% (A0; n=239 vs n=126) and 28% in 2020 (n=223 vs n=160; overall p=0.009; table 1 and figure 2). In men, A0 cases decreased by 32% (n=220 vs n=167), whereby A1 cases remained stable (0%; n=251 vs n=251; p=0.05 overall; table 1). Contradictorily, a 30% decrease in A2 cases in men was observable (n=100 vs n=70; overall p=0.05; table 1), whereas in women the number of A2 cases remained stable with −5% (n=77 vs n=73; p=0.009 overall; table 1). This trend was also evident across various daytime intervals, particularly during later hours and at night, where a general decrease in examinations and identified acute cases was observed (online supplemental figure 2).

Regarding to A0 and A1 cases, there were no significant sex-specific differences in the biological age (table 2). Although the differences in the biological age between women and men were negligible for A2 cases before the lockdown (68.6±19.6 vs 64.7±20.1; p>0.05), they became statistically significant within the lockdown period (70.3±18.3 vs 64.7±18.0; p<0.001; figure 2; table 2).

Multiple linear regression analysis revealed, the higher the age, the higher the acuity in both sexes (β_{female}=0.264; β_{male}=0.193; p<0.001 each), particularly among women admitted during the lockdown period (β_{female}=0.075; p=0.017; table 3). This was not observable for the male sex (β_{male}=0.009; p=0.758). The calculated models predicting the acuity by using the period of time and the biological age were statistically significant with F_{male} (2, 1088)=21.22 (p<0.001; R=0.194) and F_{female} (2, 948)=39.32 (p<0.001; R=0.277). Furthermore, if the acuity at admission was higher in both sexes, there was a higher probability for a relevant deterioration in the subsequent course of hospitalisation (β_{female}=0.126; β_{male}=0.148; p<0.001 each; table 3). A higher probability of a relevant clinical deterioration was not directly attributable to the period of time or the patients age (p>0.05; table 3). As well, the analysed regression models predicting the probability of relevant clinical deterioration by using the period of time, the biological age and the initial acuity were statistically significant with F_{male} (3, 1054)=8.57 (p<0.001; R=0.154) and F_{female} (3, 894)=5.67 (p<0.001; R=0.137).

DISCUSSION

A comparative and retrospective analysis was conducted to assess the impact of the COVID-19 pandemic during the initial nationwide lockdown in Germany on the patient population of a German neuroradiology department. Clinical cases from March 2020 (first hard lockdown) were compared with cases from March 2019, prior to the pandemic (n=1158 in 2019; n=884 in 2020). Overall, a 24% decrease in examinations from 2019 to 2020 was observable regarding to our department (−32% in women and −16% in men). This was consistent with several studies reporting a statistically significant reduction in the number of patient cases during this time period.[4–9] As the origin, Pfaff *et al*[4] suggested a strong correlation of decrease in medical consultation to fear of infection.[4] This was confirmed by many other international studies,[6–9] such as Nogueira *et al*,[9] revealing this effect in '40 countries across 6 continents'.[9] Willms *et al*,[13] however, suggested that (1) stricter selection criteria

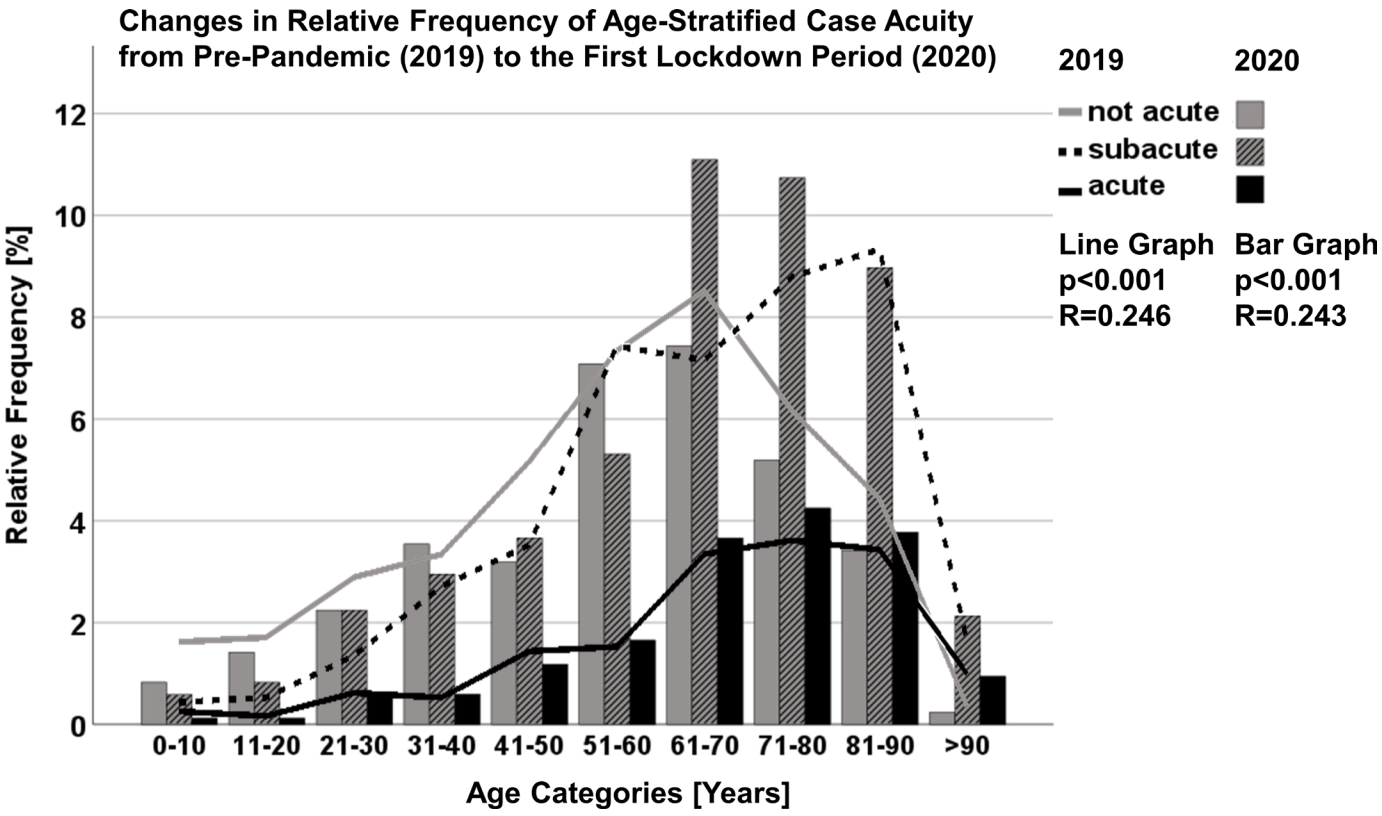

Figure 2 Overview of relative case numbers (%) by age categories in 2019 (line chart) and 2020 (bar chart). Representing the distribution of relative case numbers over the predefined period in 2019 and 2020. The data are stratified into age categories, each spanning 10-year intervals. The y-axis represents the percentage of cases relative to the age groups (x-axis). Notably, 2020 is marked as the year of the first stringent COVID-19 lockdown in Germany. The line chart showcases trends in 2019, while the bar chart illustrates the impact of the lockdown on case distribution across different age groups in 2020. In this figure, the left margin displays statistical measures associated with the corresponding regression analyses in predicting case acuity using 'age categories' and the 'period of time' as independent variables.

Table 2 Sex-specific impact of the lockdown on case acuity and mean age

		Number of cases				Age		
Sex	Acuity	Prelockdown	Lockdown	Δ (%)	P value	Prelockdown	Lockdown	P value
Female	**A0**	239 (42%)	126 (33%)	-47	**0.009**	53.7±22.3	56.2±20.8	>0.05
	A1	223 (39%)	160 (41%)	-28		65.5±18.9	63.6±21.9	
	A2	77 (14%)	73 (19%)	-5		68.6±19.6	**70.3±18.3***	
	Missing	26 (5%)	27 (7%)	+4		–	–	
	Sum	565 (100%)	386 (100%)	-32	**0.025**	–	–	
Male	**A0**	220 (37%)	167 (33%)	-24	**0.05**	56.2±20.6	55.3±20.2	>0.05
	A1	251 (42%)	251 (50%)	0		64.3±18.7	64.6±18.3	
	A2	100 (17%)	70 (14%)	-30		64.7±20.1	**64.7±18.0***	
	Missing	22 (4%)	10 (3%)	-54		–	–	
	Sum	593 (100%)	498 (100%)	16	**0.025**	–	–	

Sex-specific case acuity regarding to the number of cases and the patients' age, including not acute (A0), subacute (A1) and acute cases (A2), stratified for the period of time (prelockdown in 2019 vs lockdown in 2020). The inter sex difference of age within the A2 group became highly significant by using the Kruskal-Wallis test (p<0.001; marked with asterisks*). Differences (in %) between the prelockdown and the lockdown period were depicted as Δ (delta). The bold numbers indicate significant values.
*p<0.001.

Table 3 Multiple Linear Regression Analysis estimating Case Acuity and Relevant Clinical Deterioration of Patients by using the Period of Time (PT) and Biological Age.

		Predictor	Regression coefficient B	Stand. coefficient β	P value	R	R^2
Acuity	Male	Constant	0.342		<0.001	0.194	0.038
		PT	0.013	0.009	0.758		
		Age	0.007	0.193	**<0.001**		
	Model description		F (2, 1088)=21.22; p<0.001 Statistical power=0.99				
	Female	Constant	0.036		0.696	0.277	0.077
		PT	0.109	0.075	**0.017**		
		Age	0.009	0.264	**<0.001**		
	Model description		F (2, 948)=39.32; p<0.001 Statistical power=1				
Relevant deterioration	Male	Constant	0.253		<0.001	0.154	0.019
		PT	0.025	0.025	0.41		
		Age	0.0004	0.016	0.61		
		Acuity	0.104	0.148	**<0.001**		
	Model description		F (3, 1054)=8.57; p<0.001 Statistical power=0.98				
	Female	Constant	0.261		<0.001	0.137	0.019
		PT	0.047	0.048	0.152		
		Age	0.000	−0.011	0.744		
		Acuity	0.085	0.126	**<0.001**		
	Model description		F (3, 894)=5.67; p<0.001 Statistical power=0.95				

To predict (a) sex-specific acuity (A0=treatment within 72 hours to A2=treatment in less than 10 hours) and (b) the probability of relevant deterioration (D0=no; D1=1). As predictors (1) the period of time (PT; 0=preLockdown vs 1=lockdown), (2) Patients' age for both analysis were defined. To predict the prediction of deterioration the acuity was added as third predictor. The bold numbers indicate significant values.

and (2) patients (own will to) delaying medical consultations led to a significant decrease in emergency cases during the COVID-19 lockdown.[13] Similarly, patients with chronic diseases, such as diagnosis and active treatment for cancer, were less likely to seek medical consultations during the COVID-19 lockdown in 2020.[14] This trend was also observed in patients with other chronic diseases[15] underpinning our results regarding to the decrease in (mostly elective) MRIs and X-rays (−13% and −64%). Several studies analysing the onset of the pandemic in 2020 have observed a significant increase in anxiety and depressive disorders during and after the COVID-19 lockdown.[17–21] The general anxiety of contracting the virus and adherence to social distancing guidelines might have contributed to this decline in cases[5 15 22] leading to a higher fatality rate associated with delayed hospitalisation, Romero *et al* and Gao *et al* suggested.[23 24]

Although there were studies indicating that the number of strokes remained essentially stable during COVID-19, other studies suggested that COVID-19 patients were more likely to present with severe strokes and experience lower clinical outcomes at admission.[33] In general, the question of whether there was a significant reduction in reperfusion therapy/mechanical thrombectomy during the first COVID-19 lockdown is highly debated. Strambo *et al*[34] described no significant differences in severe stroke cases among COVID-19-positive versus negative patients but noted frequent multiterritorial involvement as a characteristic of strokes in COVID-19 patients.[34] Nogueira *et al*[9] observed a significant decrease in stroke-related treatments within the first 3 months of the pandemic situation[9] and Qureshi *et al*,[35] however, could not determine a significant correlation between the COVID-19 virus and the number of acute ischaemic strokes.[35] Alternatively, delayed hospitalisation may have contributed to the lower clinical outcomes. Jurkevičienė *et al*[36] found a significant difference in stroke severity, as measured by the NIHSS (National Institutes of Health Stroke Scale), between COVID-19-positive patients and the uninfected population (NIHSS with 16 vs 12 points).[36] They observed that higher NIHSS values in COVID-19-positive patients seemed to be unaffected by a timely and/or successful reperfusion result. Concorantly for this, Ntaios *et al*.[37] demonstrated a positive relationship between worse functional outcomes after ischaemic stroke in COVID-19-positive patients, which could be attributable to a delayed admission.[37] This suggestion was supported by Sharma *et al*[38] and Ozkan *et al*[39] through their analysis of NIHSS

scores during the COVID-19 pandemic.[38 39] Concordantly, our results revealed a strong positive correlation of the case acuity at admission on the probability of deterioration at the subsequent course of hospitalisation. Furthermore, our results revealed a significant decrease in the number of A0 (−36%), A1 (−13%) and A2 (−19%) in the lockdown period compared with the previous year. In this study, in women, there was a decrease in cases with lower severity (−47% in A0 and −28% in A1), whereby the number of cases requiring immediate treatment (A2, eg, strokes or intracranial haemorrhage) remained nearly unaffected (−5%). In line with other studies, in women, the period of time (and age) seemed to significantly influence the initial acuity of for example, strokes, suggesting that women tended to wait longer with neurological symptoms in the pandemic situation compared with the prelockdown period. This could have led to the higher case acuity observed for women at admission, nevertheless, they might have sought delayed help from the healthcare system. In contrast, among men, a decrease in both not acute (−24%; A0) and severe cases (−30%; A2) was observed between the prelockdown to the lockdown period, whereby mild cases (A1) remained stable (0%). The 30% decrease in severe cases (A2) in men could be due to a refusal to seek healthcare resulting in an increased mortality rate among male citizens while dying at home.[25 26]

The study had some limitations. Due to the high number of cases analysed (n=2042), we did not assign the study data to each of the three readers, which prevented us from analysing inter-rater reliability. However, the cases were randomised and equally distributed among the three readers by the same medical student. Nevertheless, reader-based parameters (individual evaluation of acuity and deterioration) could have been affected. Differences in assessments are likely due to this. To compensate for this, in case of uncertainty about the acuity of a case or relevant clinical deterioration for a single reader, a consensus reading was held. During this process, all three readers worked together to determine the case classification and its interpretation. Furthermore, the revealed influences of the multiple regression analysis are statistically significant, although small. Furthermore, the assessment of the ongoing clinical course focused on deterioration (D category). We did not anticipate significant improvement, which is why no corresponding classification was included in the study design. If relevant improvements in the clinical course were observed, these were categorised under D0 (‘no relevant deterioration’). At last, no investigations were conducted regarding intrapandemic situations (eg, 2021/2022), nor were individual case tracking or disease-specific progressions pursued. Such approaches would be meaningful for future studies.

CONCLUSIONS

The COVID-19 pandemic and subsequent lockdown had an impact on medical consultations, resulting in a decrease in the absolute number of consultations and an increase in cases of higher acuity overall. In women, the overall number of severe cases did not change significantly, but their proportion increased due to a decline in less severe cases. As a result, the average severity and age of cases among women rose. In contrast, increased acuity at admission during the lockdown period was attributable to women, others in men. This trend may be ascribed to a heightened pandemic-related anxiety among women; however, it did not discourage them from seeking medical help for severe symptoms. Conversely, among men, there was a decrease in the total number of severe cases, and there were no significant differences in less severe cases compared with the prelockdown period. Consequently, the average severity and age among men remained relatively stable. This could indicate a lower inclination among men to seek medical consultations and might be related to higher mortality rates occurring at home, as suggested by other studies. Overall, the likelihood of a significant deterioration in findings was not further influenced by whether people were admitted during the lockdown period or not. Only a higher acuity at admission significantly increased the probability of clinical deterioration during the hospitalisation. For future pandemic and lockdown situations, it is advisable to develop a contactless method to assess peoples’ clinical symptoms for their acuity, potentially justifying hospital admission even during night-time. This approach would aim to prevent missing acute situations where potential harm could still be effectively mitigated. The aim should be to avoid future situations where individuals refrain from seeking medical assistance due to fear of potential penalties or infections.

Contributors Conceptualisation, NH, MM-E and MAB; methodology, MM-E, SRR and MAB; software, SRR and MAB; validation, SRR, MAB and NH; formal analysis, SRR and MAB; investigation, NH and MM-E; resources, MAB; data curation, SRR, CB and MAB; writing—original draft preparation, SRR, MAB, NFG and NH; writing—review and editing, SRR, NFG, AEO, CB and MAB; visualisation, SRR and MAB; supervision, MAB; project administration, MAB; content guarantor: MAB. All authors have read and agreed to the published version of the manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and the study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards and ethical approval was waived by the local ethics committee due to the retrospective nature of the study and all the procedures being performed were part of the routine care and data analyses were reported anonymously. When admitted to hospital, the participants gave their informed consent to the future retrospective use and publication of their anonymized data for scientific purposes.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. Data are available at the Department of Neuroradiology at the University Medical Mainz. Inquiries have to be sent to the director (MAB). Each request should be based on a scientific hypothesis and reviewed by a (local) ethical committee. Any request must

be made in writing. Data will be saved for 10 years after publishing (according to GCP guidelines).

ORCID iD

Sebastian R Reder http://orcid.org/0000-0002-4193-9976

REFERENCES

1 Nieuwkamp DJ, Setz LE, Algra A, *et al*. Changes in case fatality of aneurysmal subarachnoid haemorrhage over time, according to age, sex, and region: a meta-analysis. *Lancet Neurol* 2009;8:635–42.
2 Corona-Chronologie: März 2020: NDR. 2020. Available: https://www.ndr.de/nachrichten/info/Chronologie-zur-Corona-Krise-in-Norddeutschland,coronachronologie114.html [Accessed 13 Feb 2024].
3 Günster C, Drogan D, Hentschker C, *et al*. *WIdO-Report: Entwicklung der Krankenhausfallzahlen während des Coronavirus-Lockdowns*. 2020.
4 Pfaff JAR, Harlan ME, Pfaff G, *et al*. Neuroradiological emergency consultations during the first year of the COVID-19 pandemic. *Neurol Res Pract* 2021;3.
5 Hoyer C, Ebert A, Huttner HB, *et al*. Acute stroke in times of the COVID-19 pandemic: a multicenter study. *Stroke* 2020;51:2224–7.
6 Nourazari S, Davis SR, Granovsky R, *et al*. Decreased hospital admissions through emergency departments during the COVID-19 pandemic. *The American Journal of Emergency Medicine* 2021;42:203–10.
7 Uchino K, Kolikonda MK, Brown D, *et al*. Decline in stroke presentations during COVID-19 surge. *Stroke* 2020;51:2544–7.
8 Altersberger VL, Stolze LJ, Heldner MR, *et al*. Maintenance of acute stroke care service during the COVID-19 pandemic Lockdown. *Stroke* 2021;52:1693–701.
9 Nogueira RG, Abdalkader M, Qureshi MM, *et al*. Global impact of COVID-19 on stroke care. *Int J Stroke* 2021;16:573–84.
10 Hunger R, König V, Stillger R, *et al*. Impact of the COVID-19 pandemic on delays in surgical procedures in Germany: a multi-center analysis of an administrative Registry of 176,783 patients. *Patient Saf Surg* 2022.
11 Reichardt P, Bollmann A, Hohenstein S, *et al*. Decreased incidence of oncology admissions in 75 Helios hospitals in Germany during the COVID-19 pandemic. *Oncol Res Treat* 2021;44:71–5.
12 Gil C, Beyer-Bergeot L, Sabbagh C, *et al*. Impact of the first wave of COVID-19 Epidemy on the surgical management of sigmoid Diverticular disease in France: national French retrospective study. *Int J Colorectal Dis* 2023;38.
13 Willms AG, Oldhafer KJ, Conze S, *et al*. Appendicitis during the COVID-19 Lockdown: results of a multicenter analysis in Germany. *Langenbecks Arch Surg* 2021;406:367–75.
14 Bargon CA, Batenburg MCT, van Stam LE, *et al*. Impact of the COVID-19 pandemic on patient-reported outcomes of breast cancer patients and survivors. *JNCI Cancer Spectr* 2021;5.
15 Chudasama YV, Gillies CL, Zaccardi F, *et al*. Impact of COVID-19 on routine care for chronic diseases: a global survey of views from Healthcare professionals. *Diabetes Metab Syndr* 2020;14:965–7.
16 van Ballegooijen H, Goossens L, Bruin RH, *et al*. Concerns, quality of life, access to care and productivity of the general population during the first 8 weeks of the Coronavirus Lockdown in Belgium and the Netherlands. *BMC Health Serv Res* 2021;21.
17 Huang Y, Zhao N. Generalized anxiety disorder, depressive symptoms and sleep quality during COVID-19 outbreak in China: a web-based cross-sectional survey. *Psychiatry Res* 2020;288.
18 Hwang T-J, Rabheru K, Peisah C, *et al*. Loneliness and social isolation during the COVID-19 pandemic. *Int Psychogeriatr* 2020;32:1217–20.
19 Schafer KM, Lieberman A, Sever AC, *et al*. Prevalence rates of anxiety, depressive, and eating pathology symptoms between the pre-and peri-COVID-19 eras: A meta-analysis. *J Affect Disord* 2022;298(Pt A):364–72.
20 Robinson E, Sutin AR, Daly M, *et al*. A systematic review and meta-analysis of longitudinal cohort studies comparing mental health before versus during the COVID-19 pandemic in 2020. *J Affect Disord* 2022;296:567–76.
21 Santomauro DF, Mantilla Herrera AM, Shadid J, *et al*. Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. *The Lancet* 2021;398:1700–12.
22 Rudilosso S, Laredo C, Vera V, *et al*. Acute stroke care is at risk in the era of COVID-19: experience at a comprehensive stroke center in Barcelona. *Stroke* 2020;51:1991–5.
23 Romero J, Valencia S, Guerrero A. Acute Appendicitis during Coronavirus disease 2019 (COVID-19): changes in clinical presentation and CT findings. *J Am Coll Radiol* 2020;17:1011–3.
24 Gao Z, Li M, Zhou H, *et al*. Complicated Appendicitis are common during the epidemic period of 2019 novel Coronavirus (2019-nCoV). *Asian J Surg* 2020;43:1002–5.
25 Porter A, Brown CC, Tilford JM, *et al*. Association of the COVID-19 pandemic and dying at home due to ischemic heart disease. *Preventive Medicine* 2021;153:106818.
26 Seifi A, Stowers JA, Behrouz R. Fewer hospital visits for acute stroke and acute coronary syndrome during the COVID-19 pandemic: A reality or a myth *J Neurol Res* 2020;10:53–5.
27 Universitätsmedizin Mainz. Daten und Fakten, Available: https://www.unimedizin-mainz.de/ueber-uns/daten-und-fakten.html [Accessed 13 Feb 2024].
28 Neurochirurgische Klinik und Poliklinik - Die Klinik, Available: https://www.unimedizin-mainz.de/neurochirurgie/klinik-und-team/die-klinik.html [Accessed 13 Feb 2024].
29 Willkommen in der Neurologie Mainz: University Medical Center of the Johannes Gutenberg-University Mainz, Available: https://www.unimedizin-mainz.de/fileadmin/kliniken/neurologie/Dokumente/Flyer_Willkommen_in_d_Neurologie_31102012_lay.pdf [Accessed 13 Feb 2024].
30 Hemmerich W. Statistikguru: Poweranalyse und Stichprobenberechnung Für regression. 2019. Available: https://statistikguru.de/rechner/poweranalyse-regression.html [Accessed 13 Feb 2024].
31 Hop JW, Rinkel GJ, Algra A, *et al*. Case-fatality rates and functional outcome after subarachnoid hemorrhage: a systematic review. *Stroke* 1997;28:660–4.
32 Hayes AF, Montoya AK, Rockwood NJ. The analysis of mechanisms and their contingencies: PROCESS versus structural equation modeling. *Australasian Marketing Journal* 2017;25:76–81.
33 Fuentes B, Alonso de Leciñana M, García-Madrona S, *et al*. Stroke acute management and outcomes during the COVID-19 outbreak: a cohort study from the Madrid stroke network. *Stroke* 2021;52:552–62.
34 Strambo D, De Marchis GM, Bonati LH, *et al*. Ischemic stroke in COVID-19 patients: mechanisms, treatment, and outcomes in a consecutive Swiss stroke Registry analysis. *Eur J Neurol* 2022;29:732–43.
35 Qureshi AI, Baskett WI, Huang W, *et al*. Acute ischemic stroke and COVID-19: an analysis of 27 676 patients. *Stroke* 2021;52:905–12.
36 Jurkevičienė J, Vaišvilas M, Masiliūnas R, *et al*. Reperfusion therapies for acute ischemic stroke in COVID-19 patients: A nationwide multi-center study. *J Clin Med* 2022:11.
37 Ntaios G, Michel P, Georgiopoulos G, *et al*. Characteristics and outcomes in patients with COVID-19 and acute ischemic stroke: the global COVID-19 stroke Registry. *Stroke* 2020;51:e254–8.
38 Sharma M, Lioutas V-A, Madsen T, *et al*. Decline in stroke alerts and Hospitalisations during the COVID-19 pandemic. *Stroke Vasc Neurol* 2020;5:403–5.
39 Ozkan H, Ambler G, Banerjee G, *et al*. The impact of the UK COVID-19 pandemic on patient-reported health outcomes after stroke: A retrospective sequential comparison. *J Neurol* 2022;269:1741–50.