Impact of the COVID 19 Pandemic on Radiological Imaging in Germany

Auswirkung der COVID-19-Pandemie auf die radiologische Bildgebung in Deutschland

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ABSTRACT

Purpose To analyze the impact of the COVID-19 pandemic in 2020 on the radiological imaging volume in Germany.

Materials und Methods In this retrospective multicenter study, we analyzed CT and MRI examinations of 7 radiology institutes across Germany from January to December 2020. The imaging volume was compared to 2019 (Wilcoxon-Mann-Whitney test). Modality, patient service locations, and examined body parts were assessed in consideration of time periods of the pandemic. In addition, correlation with the incidence of SARS-CoV-2 cases and associated death was performed (Spearman-test).

Results In total, in 2020, imaging volume declined by 4 % (n = 8314) compared with 2019 ($p < 0.05$). The hard lockdown during the first pandemic wave (calendar week 12–16, March 22 – April 19) revealed the highest decrease with 29 % (n = 894, $p < 0.01$), with the greatest decrease in CT (36 % vs. MRI 26 %), outpatients (38 %, $p < 0.01$), and imaging of the spine and extremities (51–72 %, < 0.05 – $p < 0.01$). Examinations referred from the emergency department (–13 %, $p < 0.05$) and CT of the chest (–16 %, $p < 0.05$) were least affected. With the end of the first wave, gradual normalization of the imaging volume was observed and persisted until the end of the observation period. A reduction of imaging volume negatively correlated with the incidence of SARS-CoV-2-positive cases and associated deaths ($r = 0.28$ and 0.49, $p < 0.05$ and $p < 0.001$).

Conclusion The COVID-19 pandemic was associated with a significant temporary decline in imaging volume. After the first lockdown period, a quick recovery was observed with radiologic imaging examinations steadily approaching prior-year figures.

Key points:

- This study assesses the impact of dynamic pandemic activity on radiological imaging in a multicenter analysis in Germany.
- The COVID-19 pandemic was associated with a temporary decline in CT and MRI scans.
- Relaxation of restrictions was associated with fast normalization of imaging volumes to prior-year levels, which persisted until the end of the year.
- Significant catch-up effects were not observed.

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ZUSAMMENFASSUNG

Ziel Untersuchung der Auswirkungen der COVID-19-Pandemie auf die Durchführung radiologischer Bildgebung in Deutschland.

Material und Methoden In dieser retrospektiven multizentrischen Studie wurden die durchgeführten CT- und MRT-Bildgebungen 7 deutschlandweiter radiologischer Zentren von Januar bis Dezember 2020 analysiert. Das Untersuchungsvolumen wurde mit dem Vorjahreszeitraum verglichen (Wilcoxon-Mann-Whitney-Test). Die Auswertung der aggregierten Daten erfolgte differenziert nach Modalität, Zuweiser, Körperregion und unter besonderer Berücksichtigung der zeitlichen Pandemieentwicklung. Die Untersuchungszahlen wurden zudem mit der Inzidenz von SARS-CoV-2-positiven Fällen und assoziierten Todesfällen korreliert (Spearman-Test).

Ergebnisse Im Pandemiejahr 2020 wurden insg. 4 % (n = 8314) weniger CT- und MRT-Untersuchungen durchgeführt als im Vorjahr (p < 0,05). Die Differenz ist vornehmlich auf den Zeitraum des harten Lockdowns (Kalenderwoche 12–16, 22. März bis 19. April 2020) zurückzuführen, welcher im Vergleich zum Vorjahreszeitraum zu einem Rückgang der Untersuchungen um 29 % geführt hat (n = 894, p < 0,01). MRT-Untersuchungen waren dabei stärker betroffen als CT-Untersuchungen (36 % vs. 26 %). Der größte Rückgang war mit –38 % (p < 0,01) bei ambulanten Patienten zu verzeichnen und bei Untersuchungen von Wirbelsäule und Extremitäten (–51 % bis –72 %, p < 0,05 bis p < 0,01). Am geringsten tangiert waren Untersuchungen aus den Zentralen Notaufnahmen (–13 %, p < 0,05) sowie CT-Untersuchungen des Thorax (–16 %, p < 0,05). Das Ende des harten Lockdowns ging mit einer sukzessiven Normalisierung des Untersuchungsvolumens auf das Vorjahresniveau einher, die auch mit Beginn der zweiten Pandemiewelle und des milderen Lockdowns am Jahresende anhielt. Der Rückgang der Untersuchungen 2020 korrelierte dabei negativ mit der Inzidenz an SARS-CoV-2-positiven Fällen und assoziierten Todesfällen (r = 0,28 und 0,49; p < 0,05 und p < 0,001).

Schlussfolgerung Die COVID-19-Pandemie in Deutschland führte 2020 temporär zu einem signifikanten Rückgang radiologischer CT- und MRT-Untersuchungen. Nach Ende des ersten Lockdowns im Frühjahr zeigte sich eine rasche Erholung der Untersuchungszahlen mit weitgehender Stabilisierung des Untersuchungsvolumens auf das Vorjahresniveau.

Introduction

The outbreak of the severe acute respiratory syndrome corona virus 2 (SARS-CoV-2) in 2020 is considered one of the greatest health policy challenges of the 21st century and it is not over. Extensive strategies were implemented around the world, including in Germany, to mitigate the effects of the pandemic. Large segments of society and the economy were temporarily shut down to achieve a lasting decrease in the number of cases and to prevent overwhelming of the health care system. In addition to the limitations placed on public life, medical facilities had to postpone any elective, non-essential imaging and procedures in order to ensure intensive care capacity and capacity for the treatment of potential COVID-19 patients in hospitals [1]. Moreover, a wide range of adjustments had to be made to workflows, e. g., changed communication and personnel structures and hygiene measures, in order to meet the treatment needs of patients and to ensure employee safety [2].

As a cross-sectional discipline, radiology is a good reflection of the general services provided and the utilization of medical care based on the examinations performed. Analyses of the first half of 2020 showed a significant decrease in radiology services [3]. At the same time, most medical disciplines recorded a dramatic decrease in treatment cases [4]. However, a longer period must be analyzed to be able to better assess possible long-term effects of the COVID-19 pandemic on health care. According to our research, there are hardly any data analyses including all of 2020 in individual disciplines and particularly in radiology.

The goal of this national multicenter study was to systematically and objectively evaluate the impact of the COVID-19 pandemic in 2020 on the radiological imaging volume in Germany in the longitudinal course.

Materials and Methods

This retrospective, multicenter study was performed in collaboration with the Working Group for Gastrointestinal and Abdominal Imaging of the German Radiological Society (DRG). The national distribution of the participating centers providing varying levels of care allows a representative analysis of radiological imaging in Germany. Seven radiology institutes participated: four university hospitals (Hannover Medical School, University Hospital Frankfurt, University Hospital Regensburg, Brandenburg Medical School Theodor Fontane) and three non-university facilities (Clemenshospital Munster, Evangelical Hospital Dusseldorf, Hospital Konstanz) (▶ **Table 1**). The study was approved by the local ethics committees of the participating centers.

Data acquisition

The examinations were extracted from the particular internal RIS of the participating centers. The aggregated data for CT and MRI examinations from January 1, 2020 to December 27, 2020 was analyzed. A weekly interval was selected for the time interval (calendar weeks, CW). The 53 rd calendar week in 2020 due to the leap year was not included in the analysis to ensure comparability with 2019. The data were compared with the same time period as the

▶ **Table 1** Clinic characteristics of the participating institutions.

Institution	Location	Numbers of beds/intensive places	Degree of medical care	Ambulatory healthcare center	Technical upgrade	Averaged regional 7-day incidence of COVID 19 in 2020
Hannover Medical School	Hannover, Lower Saxony	1520/146	maximum	no	no	23.3
University Hospital Frankfurt	Frankfurt, Hesse	130/112	maximum	no	no	35.4
University Hospital Regensburg	Regensburg, Bavaria	839/90	maximum	no	Modernisation CT	32.5
Brandenburg Medical School Theodor Fontane	Brandenburg a. d. Havel, Brandenburg	474/30	specialised medical service	no	no	9.8
Clemenshospital Münster	Munster, Northrhine-Westphalia	405/16	specialised medical service	no	no	9.0
Evangelical Hospital Dusseldorf	Dusseldorf, Northrhine-Westphalia	513/14	specialised medical service	no	no	55.4
Hospital Konstanz	Konstanz, Baden-Wurttemberg	440/24	specialised medical service	no	no	15.9

Average 7-day incidence of COVID 19 positives in 2020 in Germany: 56.4 (https://covid19.who.int/region/euro/country/de).

previous year to rule out the effect of incidental seasonal effects. The patient service location (outpatient, inpatient, or emergency room) and examined body region (head, neck, thorax, abdomen, spine, extremities, or other) were included in subgroup analyses. The imaging volume was also correlated with the positive SARS-CoV-2 cases and associated deaths published by the Robert Koch Institute [5].

Pandemic-specific phases

The following time periods were defined to represent the impact of pandemic-specific phases in Germany:

- Pre-lockdown (PRE): CW 1–11, first infections, obligation to report, and cancellation of major events.
- Hard lockdown (HLD): CW 12–16, national lockdown during the first wave of the pandemic with extensive contact restrictions and sweeping closures
- Relaxation period (RP): CW 17–23, successive easing of contact restrictions and opening of businesses
- Post-lockdown (POST): CW 24–43, extensive lifting of the restrictions listed above
- Lockdown light (LLD): CW 44-end of the year, intensification of regulations and renewed lockdown in Germany with the start of the second wave of the pandemic

Statistical analysis

Statistical analysis was performed using GraphPad Prism 9 (GraphPad Software Inc., San Diego, USA). The multicenter data were aggregated for the individual calendar weeks and tested for statistical significance after exclusion of Gaussian normal distribution via the Wilcoxon-Mann-Whitney test (differentiated according to individual body regions and patient service location separately for every modality and for the total volume compared to the entire year or the phase-specific period of the previous year). The correlation between imaging volume and the incidence of SARS-CoV-2-positive cases and associated deaths for the entire year 2020 was determined via the Spearman test. Deviations from the previous year were presented for the total numbers as well as individual parameters as the percentage difference. A probability of error of $p < 0.05$ was considered statistically significant.

Results

Total imaging volume

The total number of CT and MRI examinations in 2020 was 186 885 and was only 4 % lower than the numbers for the previous year (2019: 195 199; $p < 0.05$). 13 420 examinations were performed during HLD in Germany. This was a decrease of 29 % (18 910, $p < 0.01$) compared to the previous year (▶ **Table 2** and ▶ **Fig. 1**). The nadir was at the start of April (CW 15) with 2353 MRI and CT examinations. The average number of examinations at that time was 1938 per week compared to 2659 the previous year. With the end of hard lockdown, the number of examinations increased continuously and reached in the second half of the year a level comparable to the previous year (RP: 91 %, POST: 101 % of the imaging volume in 2019). LLD resulted again in a significant ($p < 0.05$) decrease (–2 %, 699 examinations) compared to the previous year. However, the decrease was less significant than the reduction seen during HLD.

▶ **Table 2** Imaging volume in 2019 and 2020 of seven radiological institutions in Germany according to modality.

		PRE	HLD	RP	POST	LLD	total
CT	2019	27 630	12 437	16 924	49 231	21 215	127 437
	2020	26 857 (97 %)	9265 (74 %)	15 886 (93 %)	50 856 (103 %)	21 159 (100 %)	124 023 (97 %)
p		0.30	**	0.20	0.08	0.34	0.28
MRI	2019	14 628	6473	8841	26 147	11 673	67 762
	2020	14 507 (99 %)	4155 (64 %)	7615 (84 %)	25 555 (98 %)	11 030 (94 %)	62 862 (93 %)
p		0.69	**	0.07	0.10	***	*
total	2019	42 258	18 910	25 765	75 378	32 888	195 199
	2020	41 364 (98 %)	13 420 (71 %)	23 501 (91 %)	76 411 (101 %)	32 189 (98 %)	186 885 (96 %)
p		0.75	**	0.22	0.84	***	***

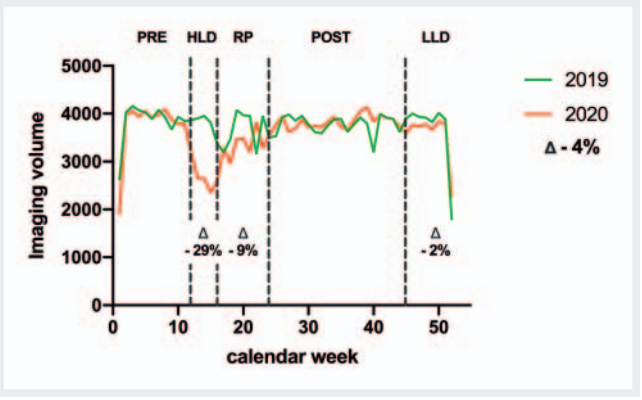
Absolute imaging volume and percentage of previous year control period are given. *p < 0.001, **p < 0.01, ***p < 0.05. PRE, Before Lockdown; HLD, Hard Lockdown; RP, Relaxation period; POST, Post Lockdown; LLD, Lockdown Light.

Modalities

The decrease in MRI examinations during HLD (decrease of 36 %, 2318, p < 0.01) was greater than the decrease in CT examinations (decrease of 26 %, (3172, p < 0.01) compared to the previous year (▶ **Table 2**). With the end of HLD, the number of examinations for both modalities increased continuously until reaching in the second half of the year a level comparable to the prior year. The number of CT examinations normalized faster and remained stable with the start of LLD. At the end of the year, the number of CT examinations was 3 % lower compared to the previous year (3414 examinations, p = 0.28). The number of MRI examinations decreased again at the start of LLD by 6 % compared to the previous year (643 examinations, p < 0.05) and at the end of the year was still 7 % lower than the previous year.

Patient service location

Cumulatively fewer inpatient cases were recorded in 2020 compared to the previous year with a difference of 5947 examinations (–7 %; p < 0.0001) (▶ **Table 3**). The number of examinations performed in outpatient care was 5 % lower than in 2019, with MRI (–8 % (p < 0.05)) seeing a greater decrease than CT (–2 %, (p = 0.84)). During HLD, a decrease in imaging volume was seen in all areas compared to the previous year. Outpatient examinations decreased by 38 % (2771 examinations, p < 0.05), followed by inpatient examinations (–27 % (2260 examinations, p < 0.01) and emergency room examinations (–14 % (429 examinations, p < 0.05). MRI was impacted in every case more than CT. The decrease in outpatient CT examinations was 4 % and was associated with a relative increase in emergency room examinations. The decrease in outpatient MRI examinations resulted in a relative increase particularly in inpatient examinations (+ 4 %, p < 0.05) (▶ **Fig. 2**). While the number of inpatient examinations remained lower over the course of the year compared to 2019, an imaging volume comparable to the previous year was reached in outpatient cases by the end of the year even during LLD (–5 %, p = 0.28).



▶ **Fig. 1** Timeline of imaging volume in 2019 and 2020. Absolute number of examinations per week in the course of the year 2020 (red) compared with 2019 (green) is shown. Significant decline within the defined periods is given as a percentage. PRE: before lockdown; HLD: hard lockdown; RP: Relaxation period; POST: post-lockdown; LLD: lockdown light.

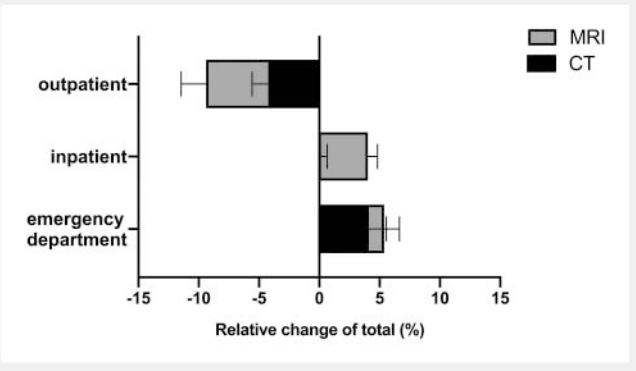
Body region

During HLD, examinations of all body regions decreased compared to the previous year (▶ **Table 4**). CT and MRI examinations of the spine (–33 % and –59 %, respectively, p < 0.05 and p < 0.01, respectively), followed by CT examinations of the neck (–33 %, p = 0.15), CT examinations of the extremities (–28 %, p < 0.01), MRI examinations of the extremities (–42 %, p < 0.01), and MRI examinations of the abdomen (–41 %, p < 0.05) were impacted most significantly. Although a significant decrease was also seen with respect to CT examinations of the chest (–16 %, p < 0.05), it was

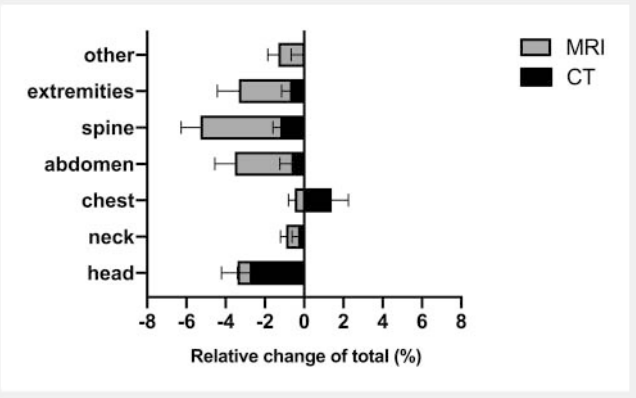
▶ **Table 3** Imaging volume in 2019 and 2020 of seven radiological institutions in Germany according to patient service locations.

		CT				MRI				total			
		2019	2020	Δ (%)	p	2019	2020	Δ (%)	p	2019	2020	Δ (%)	p
Full year	E	29 990	31 231	+4	0.06	3314	3208	–3	0.39	33 304	34 439	+3	0.08
	I	58 385	54 562	–7	**	28 128	26 004	–8	**	86 513	80 566	–7	*
	O	38 148	37 342	–2	0.84	36 324	33 723	–8	****	74 472	71 065	–5	0.28
PRE	E	6248	6137	–2	0.53	679	732	+8	0.12	6927	6869	–1	1.0
	I	12 853	12 165	–5	****	6145	5980	–3	0.90	18 998	18 145	–4	0.12
	O	8286	8422	+2	0.41	7810	7795	0	0.55	16 096	16 217	+1	0.45
HLD	E	2810	2457	–13	****	335	259	–23	****	3145	2716	–13	****
	I	5721	4277	–25	***	2701	1885	–30	***	8422	6162	–26	***
	O	3801	2456	–35	***	3437	2011	–41	****	7238	4467	–38	****
RP	E	3978	4210	+6	0.46	440	445	+1	0.78	4418	4655	+5	0.44
	I	7778	6918	–11	0.06	3721	3345	–10	0.07	11 499	10 263	–11	0.06
	O	5050	4631	–8	0.32	3437	3825	–18	0.16	9730	8456	–13	0.16
POST	E	11 904	13 221	+11	**	1275	1274	0	0.77	13 179	14 495	+10	**
	I	22 355	22 230	–1	0.24	10 888	10 552	–3	0.21	33 245	32 782	–1	****
	O	14 659	15 033	+3	0.38	13 982	13 702	–2	0.32	28 641	28 735	0	0.70
LLD	E	5050	5206	+3	0.35	585	498	–15	0.13	5635	5704	+1	0.59
	I	9678	8972	–7	****	4673	4242	–9	****	14 351	13 214	–8	****
	O	6352	6800	+7	0.15	6415	6390	0	0.08	12 767	13 190	+3	0.73

Absolute imaging volume and percentage difference (Δ) are given. *p < 0.0001, **p < 0.001, ***p < 0.01, **** p < 0.05. O, outpatients; I, inpatients; E, emergency department. PRE, Before Lockdown; HLD, Hard Lockdown; RP, Relaxation period; POST, Post Lockdown; LLD, Lockdown Light.



▶ **Fig. 2** Relative changes during hard lockdown in patient service locations. Mean ± SEM is shown.



▶ **Fig. 3** Relative changes during hard lockdown in examined body parts. Mean ± SEM is shown.

smaller than the decreases seen in the other regions. With respect to the total volume, a relative but small (1 %) increase was seen exclusively in the case of CT examinations of the chest (▶ **Fig. 3**). With the start of the LLD, a gradual increase to the level of the previous year was able to be observed for all body regions, with the exception of CT examinations of extremities (RP: 116 %; POST: 124 %, $p < 0.0001$) and CT examinations of the spine (RP: 108 %; POST: 120 %, $p < 0.001$), which saw a significant increase in some phases. There was also a continuous increase in the number of CT examinations of the chest (10 %, 660 examinations, $p < 0.001$) in the POST phase.

Correlation of the number of examinations with incidence and number of deaths

The decreasing incidence of SARS-CoV-2-positive cases and a decrease in associated deaths resulted in a recovery phase with successive normalization of the imaging volume (▶ **Fig. 4**). A weak, negative correlation for the weekly incidence ($r = 0.28$, $p < 0.05$) and a moderate, negative correlation with SARS-CoV 2-associated deaths ($r = -0.49$, $p < 0.001$) was seen.

Discussion

Using CT and MRI examinations as examples, the present multicenter study reflects the dynamics of radiology examinations performed in Germany during the pandemic year 2020.

The start of the COVID-19 pandemic resulted in a decrease in health care services in almost all disciplines. The timing of the decrease in the number of cases is closely associated with the mandated contact restrictions and the requirements for medical facilities. The present study further substantiates this. Outpatient services were particularly impacted (–38 %). This observation coincides with an analysis of medical services covered by mandatory health insurance performed by the Zentralinstitut für kassenärztliche Versorgung in Germany, which showed a significant decrease in outpatient treatment cases in all areas (imaging –39.6 %) [4]. Also, the lower number of inpatient treatment cases [6] in 2020 in Germany is reflected in our data by the consistently lower number of examinations. As expected, the smallest decrease (14 %) was seen with respect to emergency examinations with referral from the emergency room. However, this decrease was still significant compared to the previous year [7, 8]. It is not clear whether this decrease in the utilization of medical services by the population was due to the general uncertainty, fear of infection, or restrictions regarding activities and mobility. However, the significant decrease in musculoskeletal imaging, which was greater than the decrease in examinations of other body regions, could be an indication that the restrictions regarding activities played a role. This assumption is supported by the decrease in case numbers specifically in orthopedics and trauma surgery with the greatest decreases in treatment cases [9].

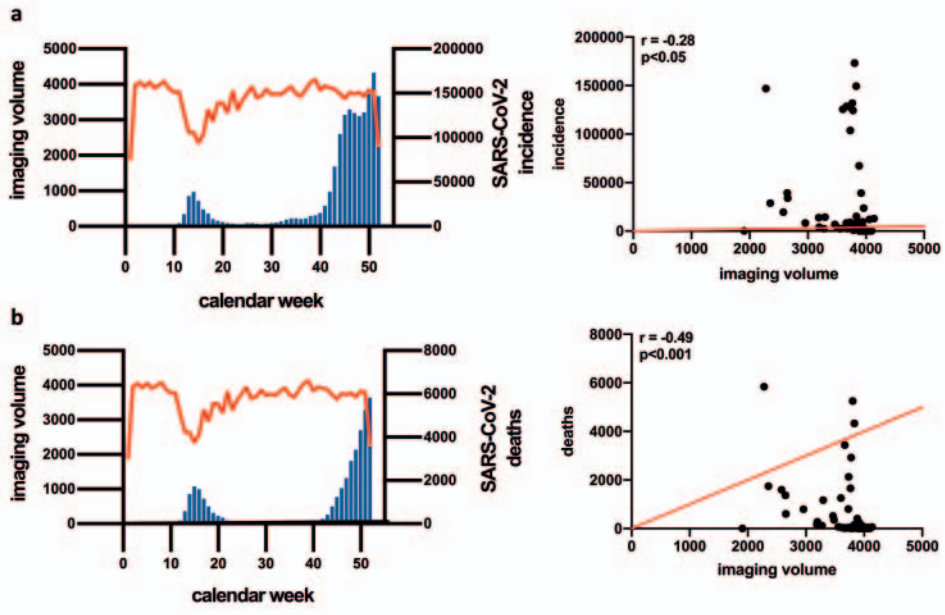
Although the decrease in the annual volume of CT and MRI examinations over the year correlated negatively with the SARS-CoV-2 case numbers and associated deaths in Germany, a noticeable stabilization of examination numbers was observed even at the start of the second wave and LLD. Although the incidence rates during this study period quickly became four times greater than those from the spring, no corresponding decrease in the number of examinations could be observed. This development shows that public perception and the utilization of medical services by patients could have played a greater role in the decrease in examinations and treatments than the reduction in medical services according to data from the German Federal Ministry of Health [10].

In spite of the partly temporary increase in the number of examinations in the second half of the year, we did not observe any significant catch-up effect. With the end of HLD and the first data regarding the decrease in medical services in almost all disciplines, some studies postulated a significant additional workload for the subsequent time in order to catch up on the services that were not performed or had been postponed. For example, based on the radiological examinations not performed during the first wave of the COVID-19 pandemic in the spring of 2020, Fleckenstein et al. calculated a significant increase in workload of up to 22 % for the second half of the year [3]. This development cannot be substantiated by our data. Instead, the imaging volume normalized to the level of the previous year so that the imaging volume for the entire year was only –4 % less than the numbers for the previous year. The absence of a compensation effect may be

▶ **Table 4** Imaging volume in 2019 and 2020 of seven radiological institutions in Germany according to body region.

		PRE		HLD		RP		POST		LLD	
		CT	MRI	CT	MRI	CT	MRI	CT	MRI	CT	MRI
head	2019	4112	2839	1848	1228	2607	1698	7516	5005	3222	2207
	2020	3962 (96 %)	2726 (96 %)	1345 (73 %)	886 (72 %)	2421 (93 %)	1593 (94 %)	7700 (102 %)	5073 (101 %)	3134 (97 %)	2104 (95 %)
p		0.40	0.29	***	****	0.21	0.30	0.37	0.61	0.62	0.12
neck	2019	507	217	240	106	322	140	895	363	391	162
	2020	506 (100 %)	180 (83 %)	160 (67 %)	68 (64 %)	355 (110 %)	98 (70 %)	903 (101 %)	291 (80 %)	405 (104 %)	121 (75 %)
p		0.94	****	0.15	0.10	0.25	0.08	0.91	****	0.68	0.09
chest	2019	3812	240	1746	104	2343	153	6472	383	2883	171
	2020	3694 (97 %)	223 (93 %)	1492 (84 %)	64 (62 %)	2417 (103 %)	131 (86 %)	7132 (110 %)	427 (111 %)	3202 (111 %)	182 (106 %)
p		0.75	0.83	****	****	0.62	0.17	***	0.09	0.14	0.72
abdomen	2019	3107	1310	1368	621	1799	745	5299	2255	2220	1002
	2020	2801 (90 %)	1254 (96 %)	1074 (79 %)	366 (59 %)	1619 (90 %)	651 (87 %)	5447 (103 %)	2422 (107 %)	2285 (103 %)	999 (100 %)
p		****	0.96	****	***	0.30	0.07	0.37	0.56	0.95	0.68
spine	2019	1062	1019	493	436	573	671	1752	1850	793	817
	2020	996 (94 %)	1021 (100 %)	332 (67 %)	221 (51 %)	620 (108 %)	506 (75 %)	2106 (120 %)	1782 (96 %)	775 (89 %)	743 (99 %)
p		0.26	1.0	***	****	0.51	***	**	0.27	0.56	0.12
extremities	2019	998	749	461	439	633	430	2111	1450	909	716
	2020	1187 (119 %)	827 (110 %)	331 (72 %)	254 (58 %)	735 (116 %)	385 (90 %)	2620 (124 %)	1462 (101 %)	929 (102 %)	594 (83 %)
p		***	0.16	***	***	0.12	0.36	*	0.62	0.55	****
others	2019	2959	928	1345	439	1922	552	5180	1689	2520	747
	2020	3188 (102 %)	918 (99 %)	1068 (79 %)	254 (58 %)	1860 (97 %)	449 (81 %)	5801 (112 %)	1741 (97 %)	2469 (98 %)	738 (99 %)
p		****	0.86	****	***	0.52	0.13	**	0.55	0.33	0.91

Absolute imaging volume and percentage of previous year control period are given. *$p < 0.0001$, **$p < 0.001$, ***$p < 0.01$, **** $p < 0.05$. PRE, Before Lockdown; HLD, Hard Lockdown; RP, Relaxation period; POST, Post Lockdown; LLD, Lockdown Light.



▶ **Fig. 4** Correlation between imaging volume and severity of the COVID-19 pandemic. Correlation between imaging volume with incidence of SARS-CoV-2-positive cases **a** and associated deaths **b** is shown.

able to be explained by the prioritization of chronically ill patients and oncology patients, whose care was largely maintained even during the worst phase of the pandemic. In spite of the quick rebound effect, it can be assumed that particularly preventative and follow-up examinations were not performed [4]. The workload in radiology departments is generally already high so that free capacity particularly for time-intensive examinations like MRI is already limited in the clinical routine. Even though efficiency can be increased to a certain extent by process optimization, e. g., the selection of shorter imaging protocols, this is not in proportion to pandemic-specific restrictions. Therefore, the increased time needed for hygiene measures, the reduced contact time, and the social distancing rules with separation of patients in waiting rooms make it difficult to expand examination capacities. Personnel resources were presumably exhausted after the lockdown phase due to postponed vacation time.

Interestingly, during HLD, a relative increase followed by an absolute increase in the number of examinations compared to the previous year was only seen in the case of chest CT examinations. Radiology clearly plays an important role in the management of suspected cases of COVID-19 and COVID-19 patients. In particular, CT was an important additional diagnostic method [11] at the start of the pandemic and also provided decisive information about the course of the disease and subsequent damage [12, 13]. In light of the novel respiratory disease, the increase in chest imaging seems plausible and also supports the high relevance of the Radiological Cooperative Network for the COVID-19 pandemic (RACOON, https://www.netzwerk-universitaetsmedizin.de/projekte/racoon) as part of the University Medicine National Research Network on COVID-19, which was used to create a national infrastructure for the systematic and structured collection of radiological data regarding COVID-19 cases.

Our study has a number of limitations. The evaluation is based on an aggregated set of data. It is probable that regional and time variations over the course of the pandemic resulted in varying degrees of changes in imaging volume in the individual facilities. Therefore, not only varying incidence rates within the states in Germany but also local outbreaks in the form of individual hotspots that presumably had a temporary effect on the services of the hospitals in the respective area were observed. Internal hospital outbreaks and varying levels of strictness of the measures implemented by the different facilities were also not taken into consideration. Our observations only relate to CT and MRI examinations. X-ray, ultrasound, and radiological interventions were not taken into consideration. It can be assumed that particularly in the case of X-rays as a basic examination but also in the case of ultrasound examinations and interventions requiring direct patient contact there would be an even greater reduction in the number of cases [3]. Specific screening examinations, particularly mammography, was probably greatly impacted by the restrictions [14, 15].

Conclusion

Our analysis shows that the number of services performed in 2020 quickly returned to the level of the previous year after a temporary decrease during HLD. In spite of the continuation of the pandemic and an increase in restrictions at the end of the year, CT and MRI imaging volumes largely comparable to the previous year were able to be achieved and mark an important element of adequate medical care.

CLINICAL RELEVANCE OF THE STUDY

- Services performed in radiology reflect the utilization of medical services and the services provided by other medical disciplines.
- The results of this study help to illustrate the impact of the current COVID-19 pandemic on medical care.
- Long-term analyses can be helpful for better adaptation of measures to be implemented in future pandemic situations.

Conflict of Interest

The authors declare that they have no conflict of interest.

Literatur

[1] Bundesministerium für Gesundheit (2020, April 27). Ein neuer Alltag auch für den Klinikbetrieb in Deutschland. Abgerufen am 19. März 2021 unter https://www.bundesgesundheitsministerium.de/fileadmin/Dateien/3_Downloads/C/Coronavirus/Faktenpapier_Neuer_Klinikalltag.pdf

[2] Finkenzeller T, Lenhart S, Reinwald M et al. Risk to Radiology Staff for Occupational COVID-19 Infection in a High-Risk and a Low-Risk Region in Germany: Lessons from the "First Wave". Fortschr Röntgenstr 2021; 193: 537–543

[3] Fleckenstein FN, Maleitzke T, Böning G et al. Decreased Medical Care During the COVID-19 Pandemic – A Comprehensive Analysis of Radiological Examinations. Fortschr Röntgenstr 2021; 193: 937–946

[4] Zentralinstitut für die kassenärztliche Versorgung in der Bundesrepublik Deutschland. Veränderung der vertragsärztlichen Leistungsinanspruchnahme während der COVID-Krise. Abgerufen am 02. Mai 2021 unter https://www.zi.de/fileadmin/images/content/Publikationen/Trendreport_4_Leistungsinanspruchnahme_COVID_2021-04-19.pdf

[5] Robert Koch Institut Abgerufen am 21 Juni 2021 unter https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/Daten/Fallzahlen_Kum_Tab.html

[6] RWI – Leibniz-Institut für Wirtschaftsforschung. Analysen zum Leistungsgeschehen der Krankenhäuser und zur Ausgleichspauschale in der Corona-Krise. Abgerufen am 05. Mai 2021 unter https://www.bundesgesundheitsministerium.de/fileadmin/Dateien/3_Downloads/C/Coronavirus/Analyse_Leistungen_Ausgleichszahlungen_2020_Corona-Krise.pdf

[7] Slagman A, Behringer W, Greiner F et al. Medical emergencies during the COVID-19 pandemic – an analysis of emergency department data in Germany. Dtsch Arztebl Int 2020; 117: 545–552

[8] Jaehn P, Holmberg C, Uhlenbrock G et al. Differential trends of admissions in accident and emergency departments during the COVID-19 pandemic in Germany. BMC Emerg Med 2021; 21: 42

[9] Bialas E, Schleppers A, Auhuber T. COVID 19: Auswirkungen des Lockdowns auf die operative Patientenversorgung in Deutschland im April 2020. Passion Chirurgie. 2020 Oktober, 10(10): Artikel 04_03; aktualisiert 16.11.2020

[10] Rees J, Papendick M, Rees Y et al. Erste Ergebnisse einer Online-Umfrage zur gesellschaftlichen Wahrnehmung des Umgangs mit der Corona-Pandemie in Deutschland. Forschungsbericht IKG. Bielefeld: Institut für interdisziplinäre Konflikt- und Gewaltforschung (IKG); 2020

[11] Vogel-Claussen J, Ley-Zaporozhan J, Agarwal P et al. Recommendations of the Thoracic Imaging Section of the German Radiological Society for clinical application of chest imaging and structured CT reporting in the COVID-19 pandemic. Rofo 2020; 192: 633–640

[12] Han X, Fan Y, Alwalid O et al. Six-month Follow-up Chest CT Findings after Severe COVID-19 Pneumonia. Radiology 2021; 299: E177–E186

[13] Balbi M et al. Post-discharge chest CT findings and pulmonary function tests in severe COVID-19 patients. Eur J Radiol 2021; 138: 109676

[14] Naidich JJ, Boltyenkov A, Wang JJ et al. Impact of the Coronavirus Disease 2019 (COVID-19) Pandemic on Imaging Case Volumes. J Am Coll Radiol 2020; 17: 865–872

[15] Lang M et al. Imaging Volume Trends and Recovery During the COVID-19 Pandemic: A Comparative Analysis Between a Large Urban Academic Hospital and Its Affiliated Imaging Centers. Acad Radiol 2020; 27: 1353–1362