The worldwide COVID-19 pandemic caused a decline in sonographic examinations – is this a continuing trend?

Die weltweite COVID-19-Pandemie führte zu einem Rückgang der sonografischen Untersuchungen – ist dies ein anhaltender Trend?

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ABSTRACT

Purpose Due to the increasing number of COVID-19 infections since spring 2020 the patient care workflow underwent changes in Germany. To minimize face-to-face exposure and reduce infection risk, non-time-critical elective medical procedures were postponed. Since ultrasound examinations include non-time-critical elective examinations and often can be substituted by other imaging modalities not requiring direct patient contact, the number of examinations has declined significantly. The aim of this study is to quantify the baseline number of ultrasound examinations in the years before, during, and in the early post-pandemic period of the COVID-19 pandemic (since January 2015 to September 2023), and to measure the number of examinations at different German university hospitals.

Materials and Methods The number of examinations was assessed based on a web-based database at all participating clinics at the indicated time points.

Results N = 288 562 sonographic examinations from four sites were included in the present investigation. From January 2020 to June 2020, a significantly lower number of examinations of n = 591.21 vs. 698.43 (p = 0.01) per month and included center was performed. Also, excluding the initial pandemic period until June 2020, significantly fewer ultrasound examinations were performed compared to pre-pandemic years 648.1 vs. 698.4 ($p < 0.05$), per month and included center, while here differences between the individual centers were observed. In the late phase of the pandemic (n = 681.96) and in the post-pandemic phase (as defined by the WHO criteria from May 2023; n = 739.95), the number of sonographic examinations returned to pre-pandemic levels.

Conclusion The decline in the number of sonographic examinations caused by the COVID-19 pandemic was initially largely intentional and can be illustrated quantitatively. After an initial abrupt decline in sonographic examinations, the pre-pandemic levels could not be reached for a long time, which could be due to restructuring of patient care and follow-up treatment. In the post-pandemic phase, the pre-pandemic level has been achieved again. The reasons for a prolonged reduction in ultrasound examinations are discussed in this article.

Key points

- During the pandemic, significantly fewer ultrasound examinations were performed in the included centers.
- The number of examinations could not be reach the pre-pandemic level for a long time, which could be due to restructuring of patient care and follow-up treatment.
- Identifying causes for sonographic exam reduction is crucial in pandemic preparedness to uphold healthcare quality and continuity for all patients.
- The prolonged decline in sonographic examinations during the pandemic does not represent a lasting trend, as evidenced by the return to pre-pandemic levels.

ZUSAMMENFASSUNG

Ziel Aufgrund der steigenden Anzahl der COVID-19-Infektionen seit dem Frühjahr 2020 wurden die Arbeitsabläufe in der Patientenversorgung in Deutschland geändert. Um die Exposition zu minimieren und so das Infektionsrisiko zu verringern, wurden nicht zeitkritische elektive medizinische Verfahren verschoben. Da Teil der Ultraschalluntersuchungen zu den nicht zeitkritischen elektiven Untersuchungen gehören und oft durch andere bildgebende Verfahren, die keinen direkten Patientenkontakt erfordern, ersetzt werden können, ist die Zahl der durchgeführten Untersuchungen deutlich zurückgegangen. Ziel dieser Studie ist es, die Ausgangszahl der Ultraschalluntersuchungen in den Jahren vor, während und unmittelbar nach der COVID-19-Pandemie (von Januar 2015 bis September 2023) zu quantifizieren und die Zahl der Untersuchungen an verschiedenen deutschen Universitätskliniken zu erfassen.

Material und Methoden Die Anzahl der Untersuchungen wurde in einer webbasierten Datenbank in allen teilnehmenden Kliniken zu den angegebenen Zeitpunkten erfasst.

Ergebnisse N = 288 562 sonografische Untersuchungen von vier Standorten wurden in die vorliegende Untersuchung einbezogen. Von Januar 2020 bis Juni 2020 wurde eine signifikant geringere Anzahl von Untersuchungen mit n = 591,21 vs. 698,43 (p = 0,01) pro Monat und einbezogenem Zentrum durchgeführt. Auch unter Ausschluss der anfänglichen Pandemiephase bis Juni 2020 wurden signifikant weniger Ultraschalluntersuchungen durchgeführt als in den Vor-Pandemiejahren, 648,1 vs. 698,4 (p < 0,05), pro Monat und einbezogenem Zentrum. In der späten Phase der Pandemie (n = 681,96) und in der postpandemischen Phase (gemäß den WHO-Kriterien ab Mai 2023; n = 739,95) kehrte die Anzahl der sonografischen Untersuchungen auf das praepandemische Niveau zurück.

Schlussfolgerungen Der Rückgang der Anzahl sonografischer Untersuchungen, der durch die COVID-19-Pandemie verursacht wurde, war anfangs weitgehend beabsichtigt und kann quantitativ dargestellt werden. Nach einem anfänglichen abrupten Rückgang der sonografischen Untersuchungen konnte das praepandemische Niveau lange Zeit nicht erreicht werden, was auf eine Umstrukturierung der Patientenversorgung und ausbleibende Nachbehandlungen zurückzuführen sein könnte. In der postpandemischen Phase wird das praepandemische Niveau wieder erreicht. Gründe für eine anhaltende Reduzierung der Ultraschalluntersuchungen werden in diesem Artikel diskutiert.

Kernaussagen

- Während der Pandemie wurden in den beteiligten Zentren signifikant weniger Ultraschalluntersuchungen durchgeführt.
- Die Anzahl der Untersuchungen konnte lange Zeit nicht das praepandemische Niveau erreichen, was auf eine Umstrukturierung der Patientenversorgung zurückzuführen sein könnte.
- Die Identifizierung der Ursachen für die Reduzierung sonografischer Untersuchungen ist entscheidend für die Pandemievorsorge, um die Qualität und Kontinuität der Gesundheitsversorgung für alle Patienten aufrechtzuerhalten.
- Der Rückgang der sonografischen Untersuchungen während der Pandemie stellt keinen dauerhaften Trend dar.

Zitierweise

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Background

The coronavirus disease 2019 (COVID-19) caused an ongoing pandemic and has raised a global public health concern. More than 220 million cases have been confirmed worldwide up to September 2021 [1, 2]. In the first period of the pandemic in Germany, the peak incidence of more than 7 cases per 100 000 inhabitants per day was reached in March 31 to April 3, 2020, while the first confirmed COVID-19 case in Germany occurred on January 27, 2020 [3, 4]. In this initial period, the treatment of critical cases of the disease required a significant number of medical resources [5]. Intensive care units had to use a substantial percentage of their ventilation capacity for the treatment of COVID-19 patients, whereas a certain additional portion of this capacity always had to be kept free for possible further severely ill patients due to the indeterminacy of the pandemic development [6]. Thus, on the one hand to ensure that the number of available beds particularly at intensive care units were kept to a sufficient level, Germany implemented a strategy of postponing elective medical procedures that are not time-critical [7, 8]. On the other hand, due to hygiene and isolation procedures, common workflows were adapted to minimize face-to-face exposure to patients and to minimize the risk of infection for patients and healthcare professionals [9, 10]. The radiology department, as a discipline interacting with almost every other discipline, played a special role during this period. On the one hand, acute COVID-19-associated

clinical pathologies had to be diagnosed, while on the other hand, other patients with an increased risk for infection had to be diagnosed [9, 11, 12].

The subdiscipline of sonography played a special role in this consideration. Due to the physically close and prolonged contact between the patient and examiner, it was attempted to shift as much of the urgent examinations as possible to other modalities (computed tomography and magnetic resonance imaging) to minimize the risk of infection in this way as well [13]. Furthermore, elective non-urgent ultrasound examinations were canceled or postponed in advance, resulting in a drastic reduction in sonographic examinations starting March 2020 [14].

Subsequently, a partial return to the pre-epidemic situation was achieved with a successive attempt to increase the number of emergency examinations and to finally resume regular elective sonographic procedures to fully restore standard patient care in Germany [15].

The aim of this study is to determine the decrease in the number of sonographic examinations due to the above-mentioned reasons and to determine if the number of sonographic examinations in the post-pandemic (from May 2023) era is similar to the number of sonographic examinations before February 2020 (first COVID-19 case on January 27, 2020) [2]. Possible explanations will be discussed.

Materials and Methods

In accordance with the guidelines of the institutional review boards, this retrospective, non-patient-centered, entirely epidemiologic multicenter analysis did not require an ethics vote. No patient-related private information was collected at any time during the investigation.

Participating institutions

Four university hospitals in Germany agreed to participate in the present study, including:

1. Institute of Diagnostic and Interventional Radiology, University of Cologne, Faculty of Medicine and University Hospital Cologne
2. Institut für Diagnostische und Interventionelle Radiologie, Universitätsklinikum Würzburg, Würzburg
3. Department of Radiology and Nuclear Medicine, Mannheim, Germany, University of Heidelberg, University Medical Center Mannheim
4. Institute of Diagnostic and Interventional Radiology, University of Frankfurt, Faculty of Medicine and University Hospital Frankfurt

Included examinations and data collection

The participating institutions were provided with an online questionnaire (*Google forms*; Alphabet Inc., Mountain View) for a detailed assessment of the ultrasound examinations performed during the included examination periods [16]. Due to data privacy regulations, only the number of conducted examinations was collected, and any information about the patient and clinical constellation was not included. The number of examinations per year from January 2015 to June 2018 was collected to generate an overview of the average number of ultrasound examinations. In the period from June 2018 to September 2023, the examinations were assessed on a monthly basis to obtain a more detailed overview of the impact of the pandemic on the number of ultrasound examinations performed.

To better illustrate the pandemic event and the sonographic examination numbers, three periods were defined:

1. Pre-pandemic period before the initial outbreak of COVID-19 in Germany in January 2020 *(January 2015 – January 2020)*
2. Pandemic period:
   a) initial pandemic period from the outbreak of the COVID-19 pandemic in Germany, including first six months *(January 2020 – June 2020)*
   b) post-initial pandemic period *(June 2020 – April 2022)*
   c) late pandemic period (May 2022 – April 2023)
3. Post-pandemic period (May 2023 – September 2023), according to WHO criteria, the official end of the COVID-19 pandemic.

Inclusion criteria:

- Completed ultrasound examination at one of the participating radiology departments (derived from the radiological information system based on the accounting department or based on DICOM tag in the picture archiving system).
- Examination between January 1, 2015, and September 30, 2023.

Exclusion criteria:

- Incomplete examinations (declined or cancelled examinations).
- Examinations performed by a department outside of the radiology department.

Statistical Analysis

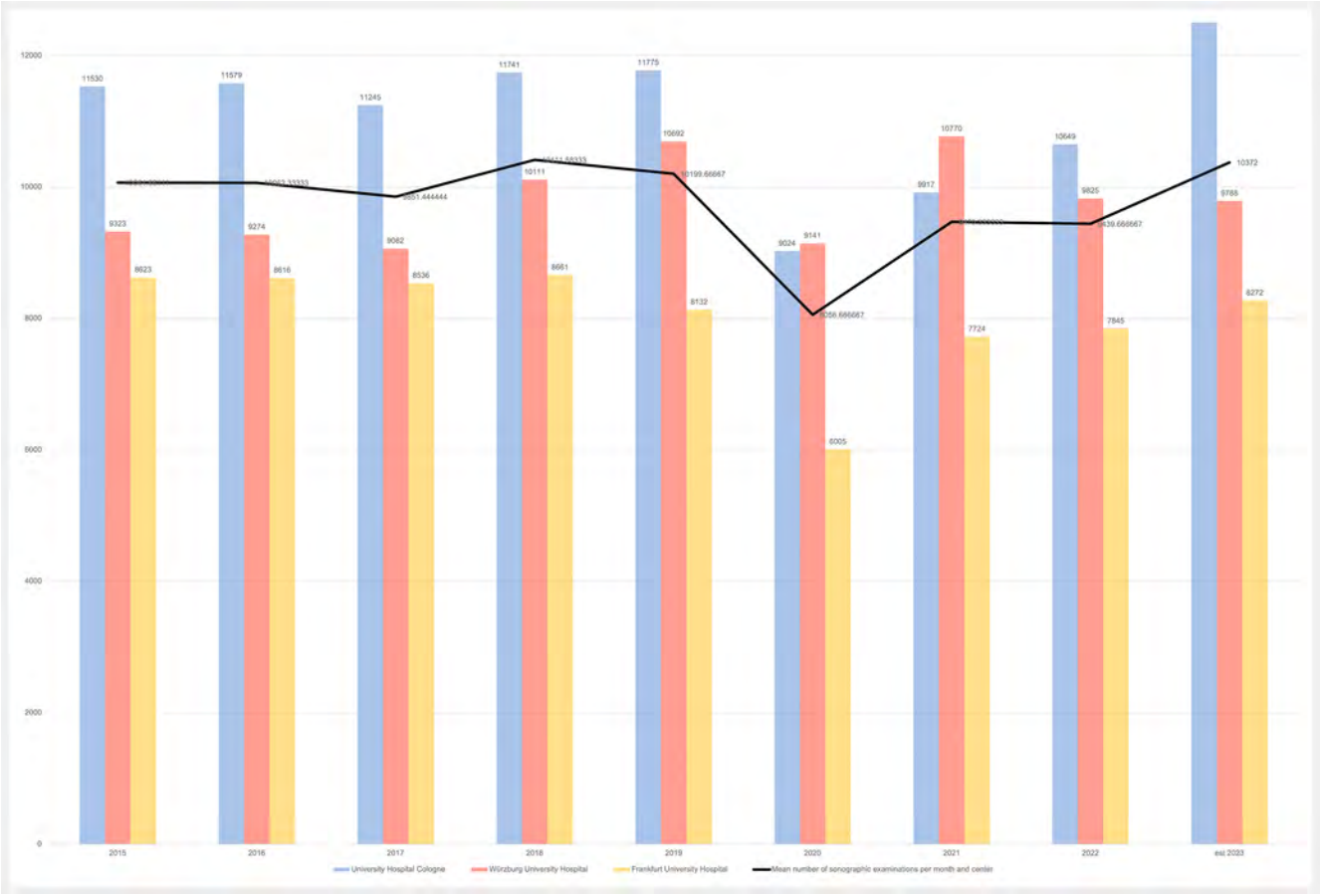
Statistical data analysis was performed using R version 3.6.2 on R studio version 1.2.5033.35 (https://cran.r-project.org/). Figures were plotted using MS Excel. Continuous variables were reported as the mean. The number of examinations performed was compared using Student's T-test. Linear regression models were used to predict the respective periods.

Results

a) Analysis of the annual examination numbers

In total, n = 288,562 sonographic examinations were included in the study from January 1, 2015 until September 30, 2023. Analyzing the total number of examinations performed in the pre-pandemic time from January 2015, the average number of sonographic examinations per month and center was n = 1051.6. In the pandemic time (initial and post-initial period) from January 2020 to April 2022, a significantly lower number of examinations (742.7) (p = 0.01) per month and included center was performed (▶ **Fig. 1**)[1].

1 Center 3 was excluded from the annual analysis due to missing pre-pandemic values before 2018 as well as the comparison to post-pandemic time due to a potential bias.



▶ **Fig. 1** Summary of examination numbers. Bar chart of the number of sonographic examinations performed at three of the four included centers from 2015 to 2023 (color-coded). Line graph of the average number of examinations performed. Center 3 was excluded from the annual analysis due to missing pre-pandemic values before 2018 as well as the comparison to post-pandemic time due to a potential bias.

b) Detailed analysis of the annual examination numbers in the individual periods of the pandemic:

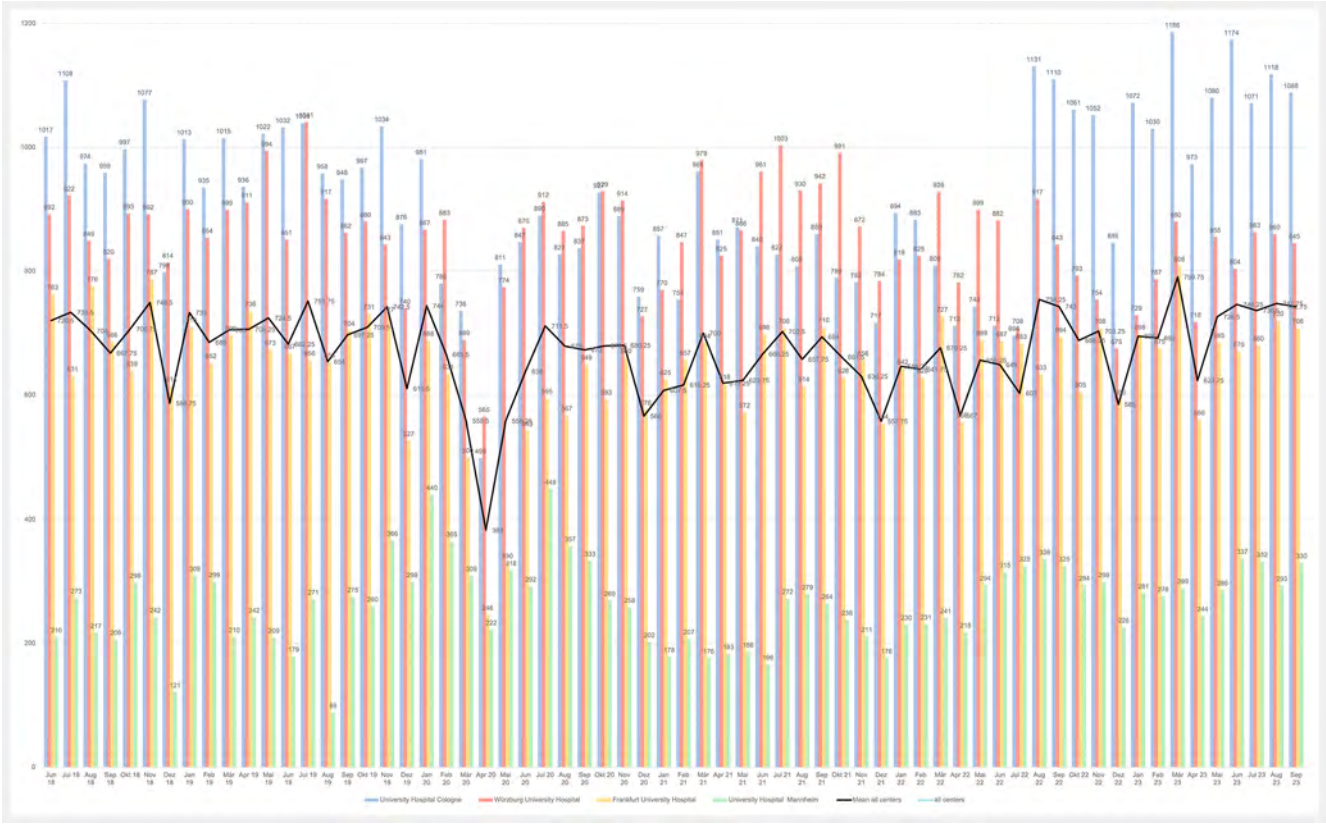
The detailed monthly analysis of the number of examinations from June 2018 to September 2023 shows a sharp decline from an average of just over 700 examinations per month and center to an all-time low of 383 examinations in April 2020. From this point on, more examinations were conducted and for the first time in June 2020, more than 700 examinations were performed on average (▶ **Fig. 2**).

It should be noted that the monthly average numbers cannot be directly transferred to the annual average numbers presented above, as another center that performed relatively fewer sonographic examinations compared to the other centers was included from June 2018 onwards.

The average number of examinations per center and month before the COVID-19 pandemic was n = 698, at the time of the initial pandemic outbreak from the end of December 2019 to July 2020 it was n = 591, and in the period after the initial pandemic-related decline in examination numbers it was n = 648 (post-initial pandemic period; significantly less than in the pre-pandemic period; $p < 0.05$; ▶ **Table 1**). Looking at the individual centers, there is a similar effect for Center 1 and Center 3 ($p < 0.05$), whereas the number of examinations in the post-initial pandemic period in Center 2 and Center 4 has returned to the pre-pandemic level ($p > 0.05$; ▶ **Table 1**).

In a linear univariate regression analysis for the three different time intervals, the number of examinations in the pre-pandemic period is prognostically constant, the number of examinations in the initial pandemic period is markedly decreased, and the number of examinations in the post-initial period is prognostically slightly decreased (for the corresponding equations and coefficients, ▶ **Fig. 3**).

In the late pandemic period (from May 2022 to April 2023), the average number was n = 681.9, which shows no significant difference ($p = 0.25$) from the pre-pandemic phase, and in the post-pandemic phase (from May 2023 to September 2023), the average was n = 739.9, which is numerically more yet not significantly higher than the pre-pandemic phase ($p = 0.056$; ▶ **Fig. 2** and ▶ **Table 1**). In all centers, the average number of monthly examinations in the late pandemic phase was not different from the pre-pandemic phase, with the exception of one center (Center 2), which still showed significantly fewer examinations compared to the pre-pandemic period (▶ **Table 1**). In the post-pandemic phase



▶ **Fig. 2** Center-specific monthly examination averages. Average number of examinations per month and center (color-coded bar charts) as well as the average number of examinations of all centers (black line).

▶ **Table 1** Report of the number of cases per month in the defined periods as well as the percentage in relation to the pre-pandemic period. Pre-pandemic period: January 2015 – January 2020. Initial pandemic period: January 2020 – June 2020. Post-initial pandemic period: June 2020 – April 2022. Late pandemic period: Mai 2022 – April 2023, Post-pandemic period: Mai 2023 – September 2023.

	Pre-pandemic period	Initial pandemic period	% pre	Post-initial pandemic period	% pre	Late pandemic period	% pre	Post-pandemic period	% pre
Cologne	984.47	775.67	78.79	833.82*	84.70	967.67	98.29	1106.23	112.364
Würzburg	882.84	774.67	87.75	879.27	99.60	798.75	90.47	845.45	95.76
Mannheim	685.68	490.17	71.49	632.59*	92.26	669.42	97.62	692.66	101.01
Frankfurt	240.74	324.33	134.73	242.00	100.52	292.00	121.29	315.61	131.02
Mean of all centers	698.43	591.21	84.65	648.06*	92.79	681.96	97.64	739.95	105.94

(from May 2023 to September 2023), all included centers did not perform significantly fewer examinations than in the pre-pandemic period. Center 1 was able to conduct significantly more examinations with an average of n = 1106.2 compared to n = 984 in the pre-pandemic period (approximately 112 %; p = 0.001). Similarly, Center 4 performed significantly more examinations with n = 315.6 compared to n = 240.7 (approximately 130 %; p = 0.001; ▶ **Table 1**).

Discussion

On the one hand, the COVID-19 pandemic brought a decrease in ultrasound examinations due to the need to keep emergency and intensive care capacities available and, on the other hand, to keep the probability of infection as low as possible. To the best of our knowledge, this is the first study to show this quantitatively, based on the example of four large radiology departments at German university hospitals focusing on ultrasound examinations. Recent research demonstrated a substantial decrease in overall radiolog-

▶ **Fig. 3** Regression analysis of monthly exam averages by time periods of the pandemic. Linear univariate regression analysis for the pandemic periods based on the average number of examinations per month and the included center.

ical examinations during the initial period of the pandemic, with trauma and orthopedics emerging as the most affected specialties [14]. In subsequent periods an increase in the total number of examinations was shown [17]. This change in trend was particularly evident in CT imaging, which saw a significant rise, likely due to its pivotal role in COVID-19 diagnostics [18].

In line with this, our data show that the COVID-19 pandemic led to a significant reduction in ultrasound examinations in Germany. Furthermore, it was demonstrated that the number of ultrasound examinations in the post-initial pandemic period was slightly decreased. However, it is noteworthy that in Center 3, there was initially a brief increase in the number of examinations from the pre-pandemic period to the initial pandemic period. In this particular case, this might have been due to the relatively low utilization of sonographic examinations in the center, so that there was no immediate need to broadly cancel these examinations. The possible reasons for the initial decline in the number of examinations are evident and described in the introduction of this paper. Nevertheless, after the initial phase of the pandemic, the sustained decrease in the number of examinations indicates that there has been a lasting change in the utilization of ultrasound within the participating radiology departments throughout the pandemic. A possible explanation for this might be that delays in ultrasound-related diagnostics during the COVID-19 pandemic may have led to more patients being referred to alternative imaging methods for both urgent and routine assessments. Moreover, the pandemic's impact on elective ultrasound examinations prompted a shift in how medical departments managed admissions, with primary care physicians possibly taking on examinations typically conducted by the radiology department (for example, the examination of lymph nodes in oncological patients). Additionally, the postponement or cancellation of examinations might have contributed to a decline in patient compliance [13–15].

In the analysis of the late pandemic and post-pandemic phases, it has been observed that the prolonged decline in ultrasound examinations had normalized to pre-pandemic levels by September 2023 across all participating centers. Notably, some centers have even recorded an increase in examination numbers. Further analyses should determine whether this trend will continue.

In this context, the current study is limited by only recording the number of examinations conducted; future studies should document the specific reasons for omitted examinations as well as any potential alternative options. Moreover, the extent to which logistical changes in the various participating centers might have additionally influenced the number of examinations is not recorded. For the purpose of "pandemic preparedness", it is crucial to understand the reasons for the cancellation of examinations.

This knowledge would enable effective adaptation of examination protocols in the event of another pandemic, incorporating other departments for ultrasound examinations, and maintaining the best possible healthcare provision for other groups, such as oncological patients, even under pandemic conditions.

Conclusion

In summary, the prolonged decline in sonographic examinations during the pandemic does not represent a lasting trend, as evidenced by the return to pre-pandemic levels. Further investigation is essential to understand in detail the factors behind this temporary reduction.

CLINICAL RELEVANCE OF THE STUDY

- Due to the increasing number of COVID-19 infections since spring 2022, the patient care workflow underwent changes in Germany.
- To minimize face-to-face exposure and reduce infection risk, non-time-critical elective medical procedures were postponed.
- Therefore, the number of ultrasound examinations performed declined significantly during the pandemic in all included centers.
- The prolonged decline in sonographic examinations during the pandemic does not represent a lasting trend, as evidenced by the return to pre-pandemic levels.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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