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Long-Term Impact of the COVID-19 Pandemic on Dental Care Delivery in Poland: A Single-Center Retrospective Analysis

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ABSTRACT

Introduction and aims: The COVID-19 pandemic has significantly impacted healthcare systems, including dentistry. This retrospective analysis aims to evaluate long-term changes in the spectrum of performed dental procedures due to the COVID-19 pandemic based on the example of the university specialized centre in Poznan.

Methods: We explored the patient dataset from the University Center of Dentistry and Specialized Medicine (Poznan, Poland) covering the period from 1 January 2017 to 31 December 2023. Services performed during the prepandemic (2017-2019), pandemic (2020), and postpandemic (2021-2023) periods were compared. Selected procedures in restorative dentistry, endodontics, dental surgery, and dental radiology were analyzed in detail, including data for both children and adults.

Results: Our study analyzed a total of 342,112 patient medical records, including 158,882 conservative procedures and 101,556 surgical procedures. During the pandemic, there was a significant reduction in conservative procedures, particularly commercial services. In the postpandemic period, the number of refunded restorations and endodontic treatments for anterior teeth increased significantly, which was not observed for commercial procedures. A notable disruption between surgical and conservative procedures occurred during the first wave of the pandemic. The prepandemic period and the first quarter of the year were more conducive to conservative and endodontic treatments.

Conclusion: The COVID-19 pandemic has led to a significant long-term shift from preventive and conservative dentistry into surgical interventions. Although the overall number of services provided has increased, more patients are opting for procedures that do not require out-of-pocket expenses.

Clinical Relevance: The pandemic has a lasting impact on the clinical decisions made by dental patients, with a greater preference for reimbursed and surgical services.

Introduction

Many external factors undeniably impact healthcare systems worldwide. Global events can affect the operation of hospitals, medical clinics, and other healthcare facilities, as well as influence patients' health-related decisions. One of the pivotal factors in recent years was the COVID-19 pandemic, which led to notable changes in the utilization of healthcare services. During the pandemic, healthcare use declined by about a third, with the most significant reduction observed among patients with less severe conditions.[1]

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It is important to recognize that the overwhelming challenges faced by medical facilities worldwide stem from a lack of preparedness. The pandemic exposed critical deficiencies in equipment, staffing, and, most importantly, a clear plan of action to guide responses.[2]

The consequences of the pandemic have affected nearly all areas of public health. Patients suffering from cancer, HIV, cardiovascular diseases, and many other chronic conditions, such as diabetes, obesity, and rheumatic diseases, experienced significant disruptions. Restrictions were also imposed on pediatric care. Furthermore, the pandemic has caused considerable harm to the mental health of the population.[3-7]

The COVID-19 pandemic had significant economic, social, and health consequences, including for oral health. The risk of infection for dental staff was high due to direct contact with patients and procedures that generated aerosols. As a result, strict restrictions were implemented to minimize virus transmission and ensure safety.[8,9] These measures included limiting preventive and routine appointments, restricting treatment to emergency cases, and reducing procedures that involved turbines, which generate aerosols and increase the risk of virus spread. Analogously, dental guidelines in Poland prioritized urgent cases, with pharmacological therapy preferred when possible.[10] Aerosol-generating procedures were limited, and enhanced protective measures, including PPE and high-efficiency air filtration, were required. Strict disinfection protocols were followed, with extended time between appointments. Teleconsultations were encouraged to reduce in-person visits, and patient triage stations were established to screen for symptoms.

Consequently, there was an increase in oral health problems among patients. However, more surgical procedures and those performed with hand tools became more common. In this context, additional training, protocols, and guidelines are essential to ensure the safety of both patients and dental staff.[11-13]

One example of the restrictions implemented to minimize contact and exposure to the virus was the reduction in the number of patients with chronic conditions, such as temporomandibular disorders and bruxism, who could receive care. These disorders did not fall under the definition of emergency cases, leaving many patients without access to dental appointments. As a result, patients experiencing pain had to rely on self-massage, stretching, thermotherapy, pharmacological treatments, relaxation techniques, or meditation to manage their symptoms.[14]

The pandemic impacted emergency dental services, routine oral health care, at-home oral hygiene practices, and dietary habits, while also contributing to an increase in the avoidance of regular dental visits and a rise in oral diseases.[15,16]

Another significant challenge affecting healthcare in Europe is the Russia-Ukraine war. By the 10th week of the conflict, over 2.3 million refugees had crossed Poland's borders, the majority of whom were women, children, and the elderly. These individuals required extensive medical support. The Polish public health system has had to provide not only social, economic, and medical care but also implement epidemiological surveillance, infectious disease prevention programs, and mental health support systems.[17,18]

Our retrospective analysis aims to assess long-term changes in the scope of dental procedures performed as a result of the COVID-19 pandemic using the example of the university specialized centre in Poznan.

Material and methods

Dataset characteristics

We analyzed the patient dataset from the University Center of Dentistry and Specialized Medicine (Poznan, Poland) from 1 January 2017 to 31 December 2023. The University of Medical Sciences in Poznan is the leading academic centre in central Poland. We focused on patient records from outpatient departments that maintained operations during the first wave of the COVID-19 pandemic in 2020, specifically the Clinic of Conservative Dentistry and Periodontology, the Clinic of Oral Surgery, and the Central Dental Clinic. We included all patients from these three clinics, both children and adults. The number of patients was determined by quarter and presented in time-dependent graphs using the 'time series' module (Figure 1).

The medical database of patients was based on the software KS-SOMED (Kamsoft). The system generated data on all visits from the examined period, taking into account demographic data (gender, age on the day of the visit) and visit data (date, clinic, performed procedure based on ICD-9, location in oral cavity). Selected procedures in restorative dentistry, endodontics, dental surgery, and dental radiology were analyzed in detail.

Statistical analysis

Services performed in the prepandemic (2017-2019), pandemic (2020), and postpandemic (2021-2023) periods were compared using the Kruskal–Wallis test with Dunn's posthoc test. The number of individual procedures was standardized against the total number of procedures performed during each period. The main findings were visualized using box plots.

We also calculated hazard ratios (HRs) for surgical procedures vs conservative procedures (restorative and endodontic) during the first wave of the pandemic (April to June 2020) and compared these with the analogous quarters of other years. To explore the relationship between long-term global factors and the spectrum of dental procedures, we performed a multidimensional correspondence analysis using a two-dimensional visualization based on the scree plot. The smaller the angle between the evaluated points, the stronger the dependence (with the vertex of the angle placed at the origin of the coordinate system).

The significance level was set at alfa = 0.05. All analyses were conducted using Statistica 13.3 (Statsoft).

Results

Distribution of patient numbers between 2017 and 2023

The distribution of patient numbers by gender in each quarter of the studied years is shown in Figure 1. Every year, there is a cyclical decrease in the number of patients during the third

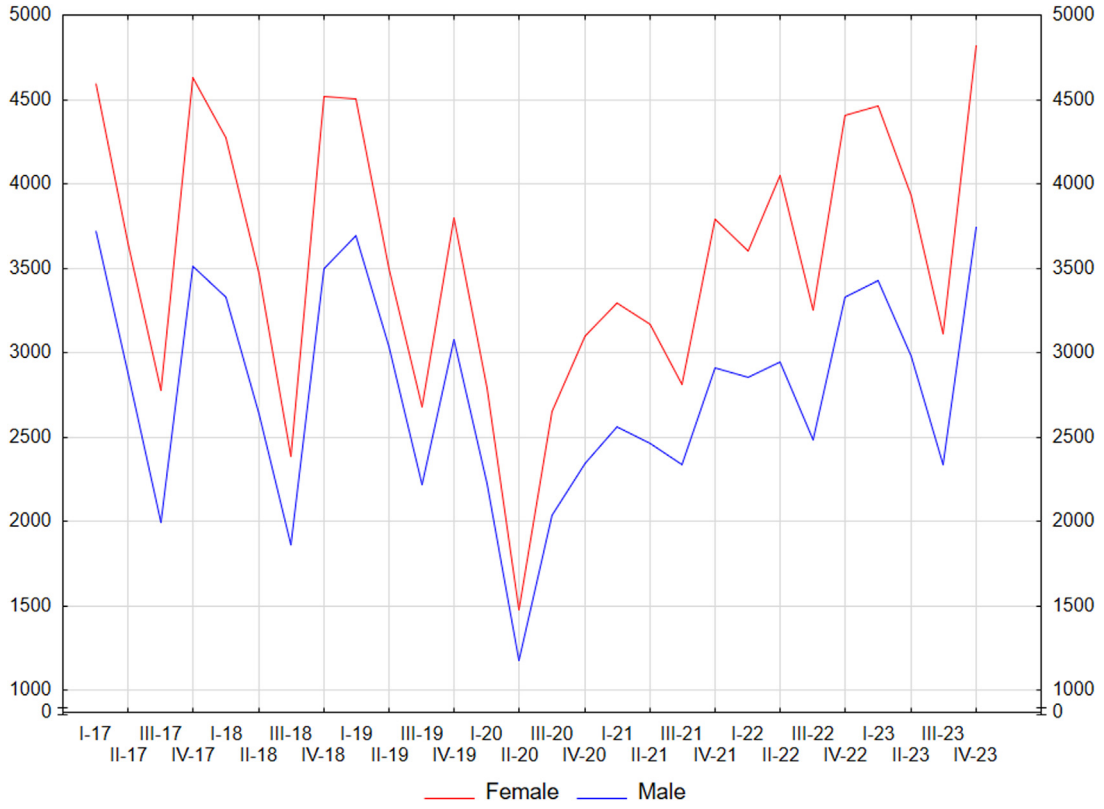

Fig. 1 – The number of patients by gender from selected outpatient departments in the University Center of Dentistry and Specialized Medicine (Poznan, Poland) from 1 January 2017 to 31 December 2023.

quarter, typically coinciding with the summer holidays. Notable increases in patient numbers are observed at the end and beginning of each year. The significant decrease in admissions during the first wave of the pandemic, particularly in the second quarter of 2020, is evident. By 2021, a strong rebound was observed, with a noticeable predominance of female patients, a trend that persisted throughout the entire study period. However, in 2022, the usual summer decline in visits was absent, likely due to the influx of war refugees from Ukraine who received dental care in Poland.

Comparison of numbers of performed dental procedures between prepandemic, pandemic, and postpandemic periods

Our study analyzed a total of 342,112 patient medical records from the University Center of Dentistry and Specialized Medicine (Poznan, Poland) covering the period from 1 January 2017 to 31 December 2023. Of these records, 158,882 were for conservative procedures, and 101,556 were for surgical procedures. Table 1 compares the range of dental procedures performed before, during, and after the pandemic.

Compared to the prepandemic period, significantly fewer conservative procedures were performed during the pandemic, particularly commercial services such as composite restorations and specialized endodontic treatments. There were no significant differences in the number of refunded restorations or intracanal dressings. In surgical procedures, there was a notable increase in abscess drainage and a rising trend in tooth extractions. Among radiological procedures, the number of periapical X-rays significantly decreased.

The number of conservative procedures increased again during the postpandemic period, though not to prepandemic levels. Refunded restorations rose significantly, a trend not observed with commercial restorations. A similar pattern was seen with endodontic treatment, where procedures significantly increased for single-canal teeth (mainly publicly refunded) but not for multicanal teeth. Interestingly, there was a continued significant increase in more advanced surgical procedures, which correlated with increased radiological diagnostic images performed.

Comparison of standardized numbers of performed dental procedures between prepandemic, pandemic, and postpandemic periods

To illustrate the participation of individual procedures over time, taking into account changes in their frequency during the study period, the number of each procedure was standardized by the total number of procedures performed each month. The results of these comparisons are presented in Table 2. A noticeable, long-term decline in the participation of tooth restorations and root canal fillings, particularly commercial ones, can be attributed to the pandemic. In contrast, there has been a significant increase in the demand for advanced surgical procedures, such as intra-alveolar and extra-alveolar extractions. However, neither interventional

Table 1 – Comparisons of numbers of selected procedures performed before (A), during (B), and after (C) the COVID-19 pandemic in the University Center of Dentistry and Specialized Medicine (Poznan, Poland) from 1 January 2017 to 31 December 2023.

Procedure	2017-2019 (A)			2020 (B)			2021-2023 (C)			*P* value	Posthoc *P* values		
	M	Q1	Q3	M	Q1	Q3	M	Q1	Q3		A vs B	A vs C	B vs C
Restorative dentistry													
Temporary filling	231.0	208.5	275.0	196.0	147.5	229.0	201.5	176.0	246.5	.009*	.015†	.099	.577
Single-surface filling	558.0	434.5	710.5	385.0	213.5	571.0	584.0	430.0	707.0	.022*	.031†	>.999	.027†
Two-surface filling	538.0	397.0	658.0	315.0	240.0	469.0	547.0	384.5	674.5	.004*	.008†	>.999	.005†
Multisurface filling	173.0	112.0	209.5	73.5	58.5	92.5	127.5	107.5	155.0	<.001*	<.001†	.048†	.004†
Filled deciduous teeth	308.5	247.5	347.0	243.5	155.5	268.5	342.0	266.0	397.5	.001*	.037†	.309	<.001†
Filled permanent teeth	1303.0	962.5	1543.0	768.5	522.0	1171.0	1247.0	902.0	1506.5	.004*	.005†	>.999	.007†
Commercial restoration	334.5	264.5	476.0	102.0	86.5	145.5	112.0	93.5	127.5	<.001*	<.001†	<.001†	>.999
Refunded restoration	917.5	621.5	1117.5	669.5	433.5	1006.0	1136.0	787.0	1415.0	.002*	.376	.047†	.004†
Endodontics													
Intervention procedure	85.0	76.0	92.5	69.0	52.0	76.5	92.5	86.5	106.0	<.001*	.014†	.004†	<.001†
Intracanal dressing	36.0	28.5	45.5	28.5	23.0	36.5	24.5	20.5	30.5	<.001*	.154	<.001†	.604
Root canal filling – single-rooted	32.0	21.0	41.5	17.5	10.5	22.5	25.5	19.0	34.0	<.001*	<.001†	.167	.042†
Root canal filling – multirooted	38.5	30.0	50.5	11.5	6.0	19.0	21.5	12.5	32.0	<.001*	<.001†	<.001†	.113
Dental surgery													
Abscess drainage	14.0	12.0	19.0	24.0	20.5	27.5	27.5	24.5	34.0	<.001*	.004†	<.001†	.285
Intra-alveolar dressing	232.0	171.0	317.0	277.0	221.5	364.5	454.0	384.0	498.5	<.001*	>.999	<.001†	<.001†
Single-rooted tooth extraction	141.5	108.5	172.5	116.5	77.0	133.5	141.0	124.0	180.0	.011*	.058	>.999	.008†
Multirooted tooth extraction	159.0	128.0	178.5	156.5	105.0	177.5	186.5	143.0	234.0	.028*	>.999	.075	.093
Intra-alveolar extraction	238.0	206.5	310.0	315.0	260.0	335.0	514.0	449.0	621.0	<.001*	.762	<.001†	<.001†
Extra-alveolar extraction	38.0	26.0	54.5	55.5	40.5	84.0	109.0	69.0	133.0	<.001*	.185	<.001†	.044†
Impacted tooth extraction	45.5	36.0	59.0	84.0	58.5	100.5	119.5	100.5	139.5	<.001*	.080	<.001†	.009†
Dental radiology													
Panoramic X-ray	330.0	247.0	387.5	303.5	230.0	337.0	429.5	354.0	495.0	<.001*	.869	<.001†	<.001†
Periapical X-ray	599.0	519.5	722.0	464.5	380.0	543.0	644.0	566.5	717.5	.001*	.010†	.803	<.001†

* Significant differences for Kruskal–Wallis test.
† Significant differences for Dunn posthoc test.

endodontic procedures nor simple extractions showed significant increases.

Figure 2 compares the standardized totals of filled, root canal-treated, and extracted teeth. It is clear that the prepandemic period was characterized by a higher proportion of conservative and endodontic procedures, with a lower proportion of surgical procedures. This trend significantly persisted into the postpandemic period.

HRs for surgical procedures (vs conservative procedures)

A significant disruption in the proportion between surgical and conservative procedures was observed during the first wave of the pandemic, as confirmed by the HR of 1.1. To further analyze this, the HRs for surgical procedures in the second quarter of subsequent years were compared, as shown in Table 3. In the years 2017 to 2019 and 2021, the HR remained at 0.3, indicating a significant predominance of conservative procedures. However, in 2022 to 2023, while the hazard for surgical procedures remained lower than for conservative procedures, the difference became less pronounced, with HR values ranging from 0.5 to 0.6.

Multidimensional correspondence analysis for relationship between global factors and the spectrum of performed dental procedures

A multidimensional correspondence analysis was conducted to graphically examine the relationship between global factors and the spectrum of performed dental procedures. Based on the scree plot evaluation, a two-dimensional analysis was selected, as shown in Figure 3. The years 2017 to 2019 (prepandemic period) and the first quarter of each year were more closely associated with conservative and endodontic procedures. In contrast, the third quarter and the years 2021 to 2023 (postpandemic period) were more favourable for surgical procedures. Detailed parameters for all points on the graph are provided in Table 4.

Discussion

Discussion on the number of performed dental procedures

Following the announcement of the COVID-19 pandemic, respected health and dental organizations such as the World Health Organization, the American Dental Association, and the Polish Dental Association issued guidelines for dental practitioners. These guidelines advised suspending routine, nonurgent oral healthcare, and aesthetic treatments while continuing to provide urgent dental care, where possible, until COVID-19 transmission rates sufficiently declined.[8-10] In response, the University Center of Dentistry and Specialized Medicine, part of the Poznan University of Medical Sciences, temporarily closed its scientific and academic operations and limited dental services to emergency care in three of its 13 still-operating clinics. The triage station had been functioning

Table 2 – Comparisons of standardized numbers of selected procedures performed before (A), during (B), and after (C) the COVID-19 pandemic in the University Center of Dentistry and Specialized Medicine (Poznan, Poland) from 1 January 2017 to 31 December 2023.

Procedure	2017-2019 (A)			2020 (B)			2021-2023 (C)			*P* value	Posthoc *P* values		
	M	Q1	Q3	M	Q1	Q3	M	Q1	Q3		A vs B	A vs C	B vs C
Restorative dentistry													
Temporary filling	0.063	0.058	0.069	0.063	0.057	0.069	0.046	0.040	0.053	<.001*	>.999	<.001†	<.001†
Single-surface filling	0.148	0.129	0.158	0.126	0.070	0.150	0.124	0.109	0.138	<.001*	<.001†	<.001†	>.999
Two-surface filling	0.142	0.128	0.147	0.114	0.081	0.120	0.112	0.105	0.132	<.001*	<.001†	<.001†	.836
Multisurface filling	0.043	0.033	0.057	0.024	0.020	0.027	0.028	0.024	0.031	<.0018	<.001†	<.001†	.365
Filled deciduous teeth	0.077	0.068	0.081	0.068	0.056	0.078	0.070	0.065	0.079	.179	n/a	n/a	n/a
Filled permanent teeth	0.330	0.300	0.349	0.269	0.174	0.297	0.269	0.241	0.294	<.001*	<.001†	<.001†	>.999
Commercial restoration	0.100	0.070	0.130	0.035	0.029	0.040	0.024	0.018	0.032	<.001*	<.001†	<.001†	.565
Refunded restoration	0.232	0.193	0.263	0.236	0.145	0.255	0.243	0.212	0.270	.143	n/a	n/a	n/a
Endodontics													
Intervention procedure	0.021	0.018	0.027	0.021	0.018	0.028	0.021	0.019	0.024	.878	n/a	n/a	n/a
Intracanal dressing	0.010	0.008	0.011	0.010	0.009	0.012	0.005	0.004	0.006	<.001*	>.999	<.001†	<.001†
Root canal filling – single-rooted	0.009	0.007	0.010	0.006	0.004	0.006	0.005	0.004	0.007	<.001*	<.001†	<.001†	>.999
Root canal filling – multirooted	0.010	0.009	0.012	0.004	0.002	0.005	0.005	0.003	0.006	<.001*	<.001†	<.001†	>.999
Dental surgery													
Abscess drainage	0.004	0.003	0.005	0.008	0.005	0.011	0.006	0.005	0.007	<.001*	<.001†	<.001†	.749
Intra-alveolar dressing	0.060	0.053	0.073	0.101	0.086	0.113	0.098	0.088	0.109	<.001*	<.001†	<.001†	>.999
Single-rooted tooth extraction	0.036	0.032	0.041	0.034	0.031	0.036	0.032	0.028	0.038	.064	n/a	n/a	n/a
Multirooted tooth extraction	0.042	0.038	0.045	0.044	0.041	0.057	0.039	0.035	0.045	.043*	.206	.994	.036†
Intra-alveolar extraction	0.063	0.052	0.074	0.096	0.083	0.118	0.117	0.107	0.126	<.001*	<.001†	<.001†	.457
Extra-alveolar extraction	0.010	0.007	0.012	0.021	0.016	0.028	0.022	0.016	0.028	<.001*	<.001†	<.001†	>.999
Impacted tooth extraction	0.012	0.010	0.014	0.026	0.020	0.030	0.027	0.024	0.030	<.001*	<.001†	<.001†	>.999
Dental radiology													
Panoramic X-ray	0.085	0.080	0.097	0.095	0.084	0.107	0.095	0.088	0.099	.036*	.204	.056	>.999
Periapical X-ray	0.160	0.151	0.174	0.158	0.142	0.169	0.137	0.132	0.142	<.001*	>.999	<.001†	.023†

* Significant differences for Kruskal–Wallis test.
† Significant differences for Dunn posthoc test.n/a, not applicable.

in our Center since the onset of the COVID-19 pandemic. In emergency situations, pharmacological therapy was prioritized, and if that was not feasible, dental procedures were performed while minimizing aerosol generation to reduce the risk of infection. Additionally, effective decontamination of the operating area was necessary between appointments, which increased the time between visits to approximately 45 to 60 minutes per patient. Our earlier paper has already documented the short-term effects of the pandemic on the centre's operations.[19] Like many other researchers, we observed a significant decline in the volume of services provided at the onset of the pandemic, particularly in the second quarter of 2020, compared to the prepandemic period.[20-22] This decline was driven not only by the limitations on patient admissions but also by high levels of fear among patients and the restrictions on mobility implemented during national lockdowns, which led to widespread cancellations or missed appointments.[23-25]

After the significant reduction in appointments, the number of visits began to rebound in the third quarter of 2020 and continued rising, eventually returning to prepandemic levels by the fourth quarter of 2023. This recovery can be attributed to the gradual lifting of restrictions in Poland, which began on 20 April 2020. Measures such as allowing free movement for recreational purposes and reopening public facilities, transportation, and services played a key role.[26] The widespread availability of free COVID-19 vaccinations also had a significant impact. Vaccination efforts in Poland began on 27 December 2020 and continued with subsequent doses. By 2 November 2024, a total of 58,599,104 vaccinations had been administered: 22,876,803 individuals received one dose, 19,759,149 received two doses, 193,915 received three doses, and 15,769,237 received a booster dose. In total, 2648,106 individuals were fully vaccinated.[27] Research by Babicki et al[28] highlighted the psychological benefits of vaccination, reporting lower levels of anxiety about COVID-19 infection among fully vaccinated Polish individuals compared to those awaiting vaccination or those with an incomplete vaccination regimen (eg, only one dose), based on an online survey.

Each year, there is a cyclical decline in dental visits during the third quarter, likely due to holiday trips taken by residents of Poznan and the surrounding area. However, in 2022, this characteristic drop in dental admissions did not occur. This anomaly may be linked to the outbreak of the war in Ukraine, following Russia's invasion on 24 January 2022. The conflict triggered a mass emigration of Ukrainian refugees, primarily women, and children, to neighbouring countries, with Poland receiving the largest number – approximately two million refugees by 19 March 2022, the highest figure among European countries.[29,30] In response to the largest refugee crisis in Europe since World War II, the Polish government implemented several immediate measures, including granting Ukrainian refugees access to free healthcare services. These services encompassed not only ambulatory care, hospital treatments, drug reimbursements, and preventive vaccinations but also dental treatment.[18]

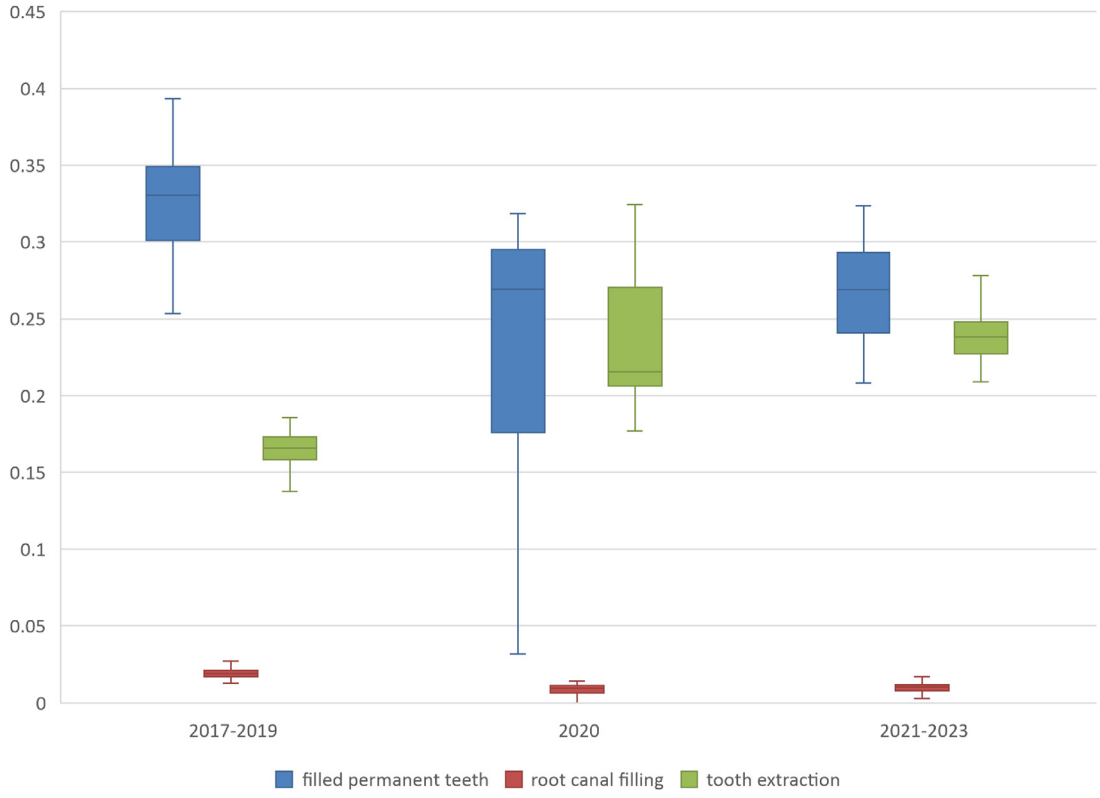

Fig. 2 – Box plot for the standardized number of tooth restorations, root canal fillings, and tooth extractions before, during, and after the COVID-19 pandemic in the University Center of Dentistry and Specialized Medicine (Poznan, Poland) from 1 January 2017 to 31 December 2023 (medians with interquartile ranges and min-max ranges; *P* value <.001 according to the Kruskal–Wallis test).

In our research, we observed a consistent predominance of females in dental care utilization throughout the entire study period. This aligns with evidence of lower interest in oral health and generally poorer oral hygiene among males.[31-33] Su et al[31] highlighted that women tend to have greater awareness of the relationship between oral health and factors such as quality of life, mood, appearance, and overall well-being. This heightened awareness translates into more frequent and regular checkups, planned treatments, and preventive oral care. In contrast, males are less likely to attend regular dental visits due to the stereotypical association of illness with a loss of masculinity and a reluctance to seek help. Instead, males tend to seek dental care primarily for acute issues, such as pain, or when directly contacted by a dentist. This disparity should alert clinicians to pay closer attention to male patients during dental visits. Efforts should focus on changing male perceptions of oral health through thorough hygiene education and detailed recommendations. Early comprehensive treatment, combined with home and office prevention strategies, should be implemented to reduce the occurrence of pain and limit the number of emergency visits in the future.

Discussion on the spectrum of performed dental procedures

Dos Santos et al,[34] in a comparison of dental procedures, reported a total reduction of over 66% (from 47 to 15.7 million procedures) in Brazil during the pandemic compared to the

Table 3 – Hazard ratios for surgical procedures vs conservative procedures (restorative and endodontic procedures) in second quarters of consecutive years between 2017 and 2023 in the University Center of Dentistry and Specialized Medicine (Poznan, Poland).

Apr-Jun	Surgical procedures	Conservative procedures	HR	−95% CI	+95% CI
2017	1692	5133	0.330	0.316	0.344
2018	1972	5920	0.333	0.320	0.347
2019	1914	5910	0.324	0.311	0.337
2020	1456	1315	1.107	1.050	1.167
2021	1662	4925	0.337	0.323	0.353
2022	3705	6030	0.614	0.596	0.633
2023	3644	6949	0.524	0.509	0.540

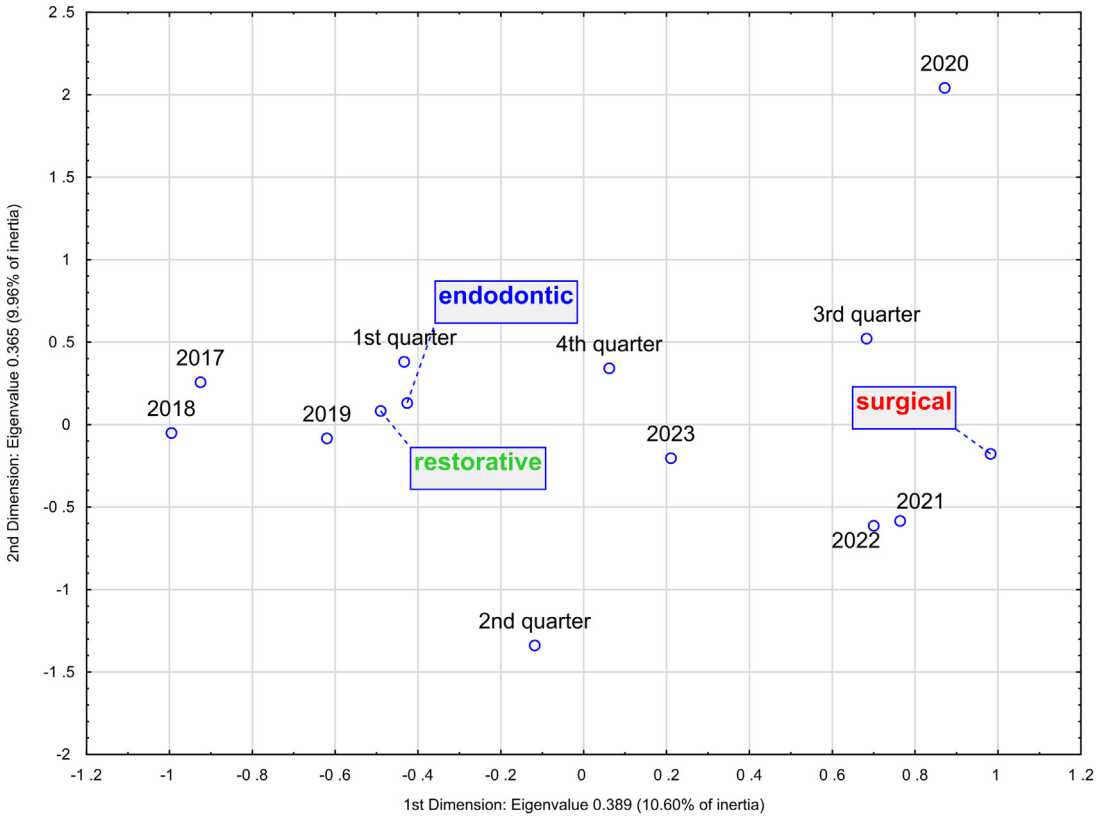

Fig. 3 – Multidimensional correspondence analysis for the impact of long-term global factors on the spectrum of dental procedures in the University Center of Dentistry and Specialized Medicine (Poznan, Poland) from 1 January 2017 to 31 December 2023 – 2-dimensional plot.

prepandemic period, based on data from the SUS Dataset. A more detailed analysis revealed statistically significant decreases across multiple categories: preventive oral health actions (−84.53%), primary care services (−60.69%), specialized endodontic care (−52.50%), and specialized periodontal and oral surgery care (−54.57%). Interestingly, two Brazilian states showed an increase in the overall number of dental procedures, which the authors attributed to the decentralized nature of Brazil's health system. However, the study did not analyze surgical procedures, such as tooth extractions. da Cunha et al,[35] using the same dataset, focused on the 30 most common dental procedures, categorized by severity, and compared their frequencies between prepandemic and pandemic periods. They identified a dramatic reduction of 88.4% in dental productivity during the first wave of the COVID-19 pandemic. The declines included a 92.3% reduction in nonemergency dental care (eg, dental consultations, scaling and planning, sealant applications) and a 72.0% decrease in

Table 4 – Detailed parameters of determined points in multidimensional correspondence analysis for the impact of long-term global factors on the spectrum of dental procedures in the University Center of Dentistry and Specialized Medicine (Poznan, Poland) from 1 January 2017 to 31 December 2023.

	x	y	Quality	Relative inertia	x inertia	x $\cos^2$	y inertia	y $\cos^2$
1st quarter	−0.433	0.382	0.130	0.065	0.045	0.073	0.037	0.057
2nd quarter	−0.118	−1.339	0.541	0.070	0.003	0.004	0.377	0.536
3rd quarter	0.683	0.522	0.174	0.074	0.076	0.110	0.047	0.064
4th quarter	0.061	0.341	0.051	0.064	0.001	0.002	0.032	0.050
2017	−0.925	0.257	0.140	0.079	0.097	0.130	0.008	0.010
2018	−0.995	−0.050	0.159	0.078	0.117	0.159	0.000	0.001
2019	−0.620	−0.084	0.062	0.078	0.045	0.061	0.001	0.001
2020	0.871	2.042	0.544	0.082	0.065	0.084	0.378	0.460
2021	0.764	−0.584	0.142	0.079	0.067	0.089	0.041	0.052
2022	0.700	−0.613	0.171	0.076	0.069	0.096	0.056	0.074
2023	0.210	−0.203	0.021	0.073	0.007	0.011	0.007	0.010
Surgical procedures	0.982	−0.178	0.490	0.061	0.273	0.475	0.010	0.016
Endodontic procedures	−0.426	0.130	0.015	0.084	0.011	0.014	0.001	0.001
Restorative procedures	−0.490	0.082	0.368	0.037	0.123	0.358	0.004	0.010

urgent dental care (eg, dental abscess drainage −98.4%, temporary endodontic treatment −63.7%). Procedures categorized as case-dependent urgency also showed notable reductions, including posterior, anterior permanent, and primary tooth restorations (−91.5%, −95.0%, −56.1%), permanent and primary tooth extractions (−87.9%, −93.6%), and interproximal or periapical radiographs (−83.4%). The researchers highlighted a smaller decline in urgent dental consultations in both primary care (−42.5%) and specialized care (−44.1%) compared to actual urgent procedures. This discrepancy may reflect a shift toward managing dental pain pharmacologically rather than through aerosol-generating procedures.

The Brazilian healthcare system, like the Polish one, provides free dental care. Similar to our findings, Brazil experienced a significant overall reduction in dental services provided during the COVID-19 pandemic, including preventive, restorative, and urgent care. However, these reductions appear to be slightly smaller than those observed in our study. One possible explanation for this difference is the fewer restrictions imposed by the Brazilian government during the pandemic. In an effort to maintain economic activity, Brazil implemented less stringent measures compared to most European and Asian countries, which ultimately led to a high number of confirmed COVID-19 cases and deaths.[34] Regrettably, there is a lack of studies evaluating the impact of COVID-19 on the Brazilian dental care system in the years following the pandemic.

Another short-term study conducted by Dill et al[36] examined the impact of COVID-19 on oral health care in the United States following the reopening of dental offices (July 2020 to December 2021). Similar to our findings, they reported that the volume of oral health care did not rebound to prepandemic levels, particularly in diagnostic and preventive procedures across all age groups except those aged 65 years and older. The study also identified a significant decrease in direct restorations (amalgam and resin) and an increase in prefabricated restorations, such as stainless-steel crowns, in children aged 0 to 5 and 6 to 18 years. This trend was attributed to more severe and extensive caries due to delayed dental care, increased sugar consumption, and more frequent snacking while staying at home during the pandemic. Interestingly, there was a notable increase in the use of occlusal guards among patients aged 19 to 64 years and those 65 years and older. The authors linked this trend to heightened stress and bruxism since the onset of the pandemic. Conversely, they observed a decrease in palliative care across almost all age groups, with the smallest reduction seen in individuals aged 65 and older. Moreover, they considered the effects of teledentistry and the delivery of definitive (rather than intermediate) treatments during the pandemic. Outcomes in conservative dentistry and surgery varied, with both statistically significant and nonsignificant results, although a dominant decrease was observed in most quarters.

In our view, the significant increase in refunded surgical procedures during and after the pandemic, coupled with the notable decrease in commercial conservative procedures, may be attributed to the economic impact of the pandemic. This includes both the rising costs of commercial dental services and the financial difficulties faced by patients.[37-40] Our Center, as the largest regional facility financed by the National Health Fund, primarily relied on providing reimbursed services during this challenging period when smaller clinics could not afford adequate personal protective equipment due to the pandemic economic recession. Meanwhile, the prices of commercial services gradually increased following periodic reviews in response to postpandemic inflation. However, as a specialized centre for pre- and postgraduate education, we continue to offer competitive prices in the market.

The marked rise in definitive procedures, such as tooth extractions, could also be a consequence of the brief but impactful disruption in preventive and maintenance dental care during the second quarter of 2020. During this period, dental practitioners focused primarily on urgent treatments and pain management. The absence of regular preventive care and monitoring likely contributed to the progression of caries, worsening of periodontal conditions, or tooth fractures – among the most common reasons for extractions.[41] Reversing this trend is crucial. There is an urgent need to enhance patient awareness of oral health and emphasize the importance of dental prophylaxis and conservative treatment.

Other researchers have also noted that conservative dentistry was the most affected field during the pandemic.[42] However, most of these studies focus on the short-term effects during or immediately after the onset of the pandemic, without extending into 2021 or beyond. The strength of our study lies in its ability to highlight the long-term consequences of COVID-19 on dental procedures at the University Center of Dentistry and Specialized Medicine. As a leading academic centre in central Poland with a large patient base, the centre operated continuously, even during the initial weeks of the epidemic.

Study limitations

There are several limitations to our study. Due to the uninterrupted operation of only three clinics, our analysis was based on a limited sample. This may have influenced the final results, as other clinics also provide conservative and surgical procedures, particularly in undergraduate and postgraduate education, which were suspended during the first wave of the pandemic. Additionally, our analysis was restricted to the database available only within our dental centre. Unfortunately, Poland lacks a publicly available national database on patient health, similar to the one in Brazil, which limits our ability to compare data on a broader scale. Even if such a database existed, it would only include reimbursed procedures, not commercial ones, potentially skewing the study results. Furthermore, it was impossible to distinguish regular patients from those visiting for the first time due to the closure of their regular dental offices, particularly those from distant areas of Greater Poland.

Conclusions

The COVID-19 pandemic exposed critical weaknesses in dental healthcare systems, emphasizing the need for better preparedness in future global health crises. Our findings

highlight the significant lasting impact of the pandemic on the spectrum of performed dental procedures. The temporary suspension of routine dental services and the prioritization of emergency care during the COVID-19 pandemic shifted the focus away from preventive and conservative dentistry. This change resulted in an increased trend in surgical interventions, which persisted postpandemic.

Economic factors, including the increased costs of commercial services due to postpandemic inflation, likely contributed to the observed patients' shift toward refunded procedures. Additionally, delayed routine dental care during the pandemic exacerbated oral health issues, culminating in the rise of surgical procedures, such as tooth extractions. Gender differences in dental care utilization were notable, with females consistently representing a larger proportion of patients, underlining the need for targeted strategies to encourage males to engage in preventive and routine oral healthcare. Further research is needed to explore the individual factors influencing patients' dental treatment decisions.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

Data availability

The data are available from the corresponding author upon reasonable request.

Ethics statement

This is a retrospective study. The Bioethics Committee of Poznan University of Medical Sciences has confirmed that no ethical approval is required.

Author contributions

Conceptualization: KŁ, KN; Data curation: KŁ, KN; Formal analysis: KŁ, KN; Investigation: KŁ, MO, ACJ, AS, KN; Methodology: KŁ, KN; Supervision: KN; Visualization: KN; Writing – original draft: KŁ, MO, KN; Writing – review and editing: KN.

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