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RESEARCH

The impact of general medical health status, demographical, and patient-specific variables on need for dental treatment of children and adolescents under general anesthesia

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Abstract

Objectives Aim of this retrospective study was to examine the influence of general medical, demographical, and other patient-specific factors on the need for dental treatment under general anesthesia in children and adolescents at Saarland University Hospital. For assessment of the clinical treatment need, a mixed dt/DT (decayed teeth) was introduced.

Materials and methods A total of 340 patients under 18 years of age who received restorative-surgical dental treatment between 2011 and 2022 were anonymously enrolled. Demographic and other patient-specific data, general medical health, oral health, and treatment related data were recorded. In addition to descriptive analysis, Spearman-Rho-test, Mann–Whitney-U-test, Kruskall-Wallis-test and Chi-square-test were used.

Results More than half of the patients (52,6%) were in general health, but non-cooperative. The majority of the patients (66.8%) was between 1 and 5 years of age ($p < 0{,}001$). Mean dmft was 10.95 ± 4.118, mean DMFT was 10.09 ± 7.885, and mean dt/DT was 10.79 ± 4.273. Analysis showed that communication difficulties significantly influenced dmft ($p = 0.004$), DMFT ($p = 0.019$), and dt/DT ($p < 0.001$). Type of insurance significantly affected dmft ($p = 0.004$) and dt/DT ($p = 0.001$). There was no significant effect of ASA on caries experience, however on prevalence of severe gingivitis ($p < 0.001$), number of extractions ($p = 0.002$), and need for repeated treatment ($p < 0.001$).

Conclusions Need for dental treatment in the present collective was high, independent of the considered variables. Non-Cooperativeness along with ECC was the main indication for dental general anesthesia. The mixed dt/DT was the most precise survey to evaluate clinical treatment needs.

Clinical relevance Given the enormous demand for these rehabilitations with strict selection, it is imperative to create more treatment capacities for patients mandatorily requiring general anesthesia by avoiding it in healthy patients.

Keywords Early childhood caries · Dental treatment · Dental general anesthesia · Children and adolescents · Non-cooperative children · Special healthcare needs

Introduction

The caries experience of children and adolescents in Germany has decreased over the last 20 years due to improved oral hygiene and preventive measures. Nevertheless, there are many cases of patients under 18 years of age revealing high numbers of carious teeth in the first, mixed, and second dentition. As early as 3 years of age, more than 10% of children suffer from untreated Early Childhood Caries (ECC) [1]. The main reason for this is sugary diet. In particular in ECC, the consumption of sweet beverages via nursing bottles plays a major role [2, 3]. Often, children do not visit a dentist until caries is far advanced. Untreated caries can lead to pain, infection, gingivitis, periodontitis, dysfunction, and

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malnutrition, resulting in urgent need for dental treatment [4, 5]. As caries is influenced by behavior, mental disabilities, physical disabilities, and other general diseases can promote the progression of caries, through the lack of compliance, mental and motor disorders, as well as missing caregiver support [6]. Many studies have confirmed that non-healthy children usually have a higher caries experience than healthy children in the primary and mixed dentition [7-10]. In particular in these non-healthy patients, the consequences of untreated caries can seriously affect their general health [5].

Socioeconomic factors like education level, family income, social status or type of insurance can also strongly influence the caries experience [3, 11-13]. In educationally deprived and socially disadvantaged families, daily oral hygiene and regular dental examinations have a lower priority, although unbalanced and high-carbohydrate diet is mainly prevailed [3, 14, 15].

Biological age, extent of treatment, non-compliance, anxiety, mental and physical disabilities, and general illness can significantly complicate dental treatment under office conditions and may be indications for dental treatment under sedation or general anesthesia [16, 17]. Due to the fact that enteral moderate sedation with benzodiazepines limits treatment time to approximately 30 min, beside nitrous oxide, general anesthesia has become a common way to comprehensively restore oral health of non-cooperative patients and those in need for special care [16, 18]. Nevertheless, any general anesthesia carries risks and should be considered only, if conventional chairside treatment proves impossible. In particular, general anesthesia may be more difficult in patients with special health care needs due to medical risk factors. The post treatment recovery period is also comparatively longer [18]. Therefore, the goal should be long-term dental rehabilitation in one step to avoid or at least to reduce repeated treatment under general anesthesia. In addition to successful dental rehabilitation, regular follow-up is essential to ensure long-term oral health [19].

In our department, restorative-surgical dental rehabilitations under general anesthesia have been successfully performed in non-cooperative, mentally and/or physically challenged, or chronically ill children and adolescents for decades, even if these treatments are severely limited.

The aim of this retrospective study was to describe the characteristics of our patient collective and to check the influence of general medical health status, demographical and other patient-specific factors on the need for dental treatment under general anesthesia. Therefore, the mixed dt/DT (decayed teeth) index was included, recording all decayed teeth at the initial visit, regardless of whether they were primary or permanent teeth. It allows to visualize the need for treatment independent of age and, therefore, being the most important survey. In contrast, the caries experience indices dmft and DMFT (decayed, missing, filled, teeth) are age-dependent and might be imprecise to evaluate the clinical treatment need, in particular in patients with mixed dentitions. There are no studies dealing with this problem. In addition, this study was designed to verify the success of dental treatments under general anesthesia in our department.

Materials and methods

Subjects

The study included all patients under 18 years of age who received restorative-surgical dental treatment under general anesthesia at the Clinic of Operative Dentistry, Periodontology and Preventive Dentistry at Saarland University Hospital between August 17th, 2011 and May 25th, 2022. Patients older than 18 at time of treatment or patients who primarily required surgical treatment only, were excluded.

The treatments under general anesthesia were performed by the Clinic of Operative Dentistry, Periodontology and Preventive Dentistry in premises of the Department of Oral and Maxillofacial Surgery at Saarland University Hospital. The indication for general anesthesia was only made when several treatment attempts in office conditions failed due to lack of compliance. Furthermore, general anesthesia was performed, when the medical condition of patients required treatment under general anesthesia or when extent of needed treatment in young children required quick action. After treatment, the patients were monitored inpatient until the next day. Sedation methods are generally not carried out in our department.

A total of 340 patients were enrolled. Once, they were divided into groups according to their anamnestic history: namely healthy/non-cooperative patients, mentally disabled and/or physically disabled patients, patients with general diseases and patients with mental disability and/or physical disability along with general diseases.

To compare the general medical health status to other studies, the patients were classified according to the American Society of Anesthesiologists Physical Status Classification System (ASA-PS). This is the commonly used classification system for anesthesiologists to rank the medical health status of patients and thus assess the risks during treatment. It includes 6 ASA levels from healthy (ASA 1) to brain-dead (ASA 6). The higher ASA the higher the degree of illness and potential risks [20, 21].

In addition, patients were grouped based on general demographics and other patient-specific data. The monitoring of patients was performed from initial examination to treatment and follow-up. Treatment mainly included dental fillings and extractions, fewer professional tooth cleanings, steel crowns and endodontic treatments.

Study design

The study was designed as retrospective analysis and approved by the Ethics Committee of the Saarland Medical Association (289/21). Data collection was conducted in 2022 via the dental patient record software Dampsoft (Dampsoft GmbH, Germany) and the general clinic software SAP (SAP Deutschland SE & Co. KG, Germany).

All data were compiled in anonymized form in a customized table in Microsoft Excel (Microsoft Corporation, USA). The general patient parameters recorded were biological age, biological gender, type of health insurance, type of referral, communication difficulties and distance from home. The criteria for communication difficulties were defined by the need for an interpreter or that the medical history form was filled in another language.

The general medical data collected were medical history and ASA.

The oral health data collected were dmft/DMFT, mixed dt/DT, ECC type and occurrence of severe gingivitis. The dmft and DMFT are used as standard indices in clinical investigations and epidemiological studies to capture caries experience of patients. It includes decayed, already missing and filled teeth. The dmft considers primary teeth, the DMFT permanent ones [22-24]. The mixed dt/DT captures all decayed teeth independent of dentition at time of examination and was used in this study for the first time. The ECC typification according to Amjad Hussain Wyne, used in this study, describes the degree and form of caries disease in preschool children. ECC type 1 (mild to moderate) describes isolated caries on molars or incisors. ECC type 2 (moderate to severe) describes caries affecting the upper incisors with or without molars, also called,,The Nursing Bottle Syndrome''. ECC type 3 (severe) describes caries affecting almost all teeth, including the lower incisors [25]. The criteria for defining the presence of severe gingivitis were only based on clinical documentation.

The data collected related to treatment were date of treatment, intubation type, number of professional tooth cleanings, number of dental fillings, number of tooth extractions, number of steel crowns, number of endodontic treatments, number, and type of complications during and after treatment, follow-up and number of repeated treatments under general anesthesia. In addition, the number of pulp openings during treatment was recorded, describing when a pulp was opened during caries excavation due to deep caries. In this case, teeth must be extracted as endodontic treatments in our department are not usually performed under general anesthesia.

Analysis

The data analysis utilized IBM SPSS 28 (IBM Deutschland GmbH, Ehningen, Germany). A general descriptive analysis was carried out. Normal distribution was checked by use of the Shapiro–Wilk test. The significance level was set at $p = 0.05$. Testing the hypotheses, the Spearman-Rho-test, the Mann–Whitney-U-test, the Kruskall-Wallis-test and the Chi-square-test were performed.

Results

Demographic and patient-specific data

The age range in the present collective was from 1 to 16. Mean age was 5.19 ± 3.38. Separated by age groups, the 1–5-year aged children formed the largest proportion with 70% ($n = 238$). Gender distribution shows that male patients dominated with 58.5% ($n = 199$). Male patients represented the largest proportion in all age groups.

Over 90% of the patients, in fact 95.6%($n = 325$) were covered by a general health insurance, 4.4% ($n = 15$) by private insurance. The majority of the patients, 48.5% ($n = 165$), were referred by their family dentist. The remaining patients came on their own initiative or were referred by other departments.

The mean travel distance from home to the dental clinic was 40.82 ± 48.86 km, 70.9% ($n = 241$) of the patients travelled less than 50 km to the treatment site, 29.1% ($n = 99$) travelled more than 50 km. Less than 10% came from a radius of at least 80 km and 7% of at least 100 km.

Communication difficulties were found in 11.2% ($n = 38$) of the patients (Table 1).

General medical health data

According to anamnestic history, healthy/non-cooperative patients accounted for 52.6% ($n = 179$), followed by patients with general diseases (25.3%, $n = 86$), patients with mental and/or physical disability (11.5%, $n = 39$), and patients with mental and/or physical disability together with general diseases (10.6%, $n = 36$) (Table 2).

Regarding the age distribution in groups according to anamnestic history, healthy patients under 4 years of age formed the largest subgroup. Between 5 and 6 years of age, healthy patients and patients with general illnesses were equal. From 9 years of age, the proportion of healthy patients decreased and patients with general diseases, mental and/or physical disabilities made up the majority. In particular, patients with mental and/or physical disabilities together

Table 1 Demographic data and other patient-specific data in percent and assigned to number of cases

	Age			Gender		Health insurance		Referral				Communication difficulties	Approach	
	1–5	6–12	13 +	Female	Male	General	Private	General dentist	Other department	Pediatrist	Unknown		< 50 km	> = 50 km
n	238	80	22	141	199	325	15	165	30	3	142	38	241	99
%	70,0	23,5	6,5	41,5	58,5	95,6	4,4	48,5	8,8	0,9	41,8	11,2	70,9	29,1
Minimum	1												0 km	
Maximum	16												723 km	
∅	5,19 ± 3,383												40,82 km ± 48,862	

with general diseases increased from this age on. In summary, younger patients made up the majority of healthy patients ($p < 0{,}001$) (Fig. 1 and Table 2).

Patients with ASA 1 accounted for 52.1% ($n = 177$), ASA 2 34.4% ($n = 117$) and ASA 3 13.5% ($n = 46$). Regarding to age groups, ASA 1 dominated in 1–5-year-olds. The proportion of healthy patients decreased with increasing age ($p < 0{,}001$), in the group of 13 years and older no patients were classified as ASA 1 (Table 2).

There were no significant differences between boys and girls regarding the groups according to anamnestic history ($p = 0{,}341$) and ASA ($p = 0{,}706$).

The most common diseases among non-healthy children were cardiovascular, neurological, and syndromic diseases with gene defects (Fig. 2).

Oral health data

Severe gingivitis was documented in 5.9% ($n = 20$) of patients. With increasing ASA the prevalence for severe gingivitis significantly increased ($p < 0{,}001$).

Mean dmft was 10.95 ± 4.11. Maximum dmft was 20. Mean DMFT was 10.09 ± 7.88. Maximum DMFT was 26. Mean mixed dt/DT was 10.79 ± 4.27. Maximum dt/DT was 24 (Table 3).

There was no significant effect of biological age on dmft ($p = 0{,}956$), DMFT ($p = 0{,}084$) or dt/DT ($p = 0{,}352$). Gender did not influence dmft ($p = 0{,}364$) or dt/DT ($p = 0{,}713$) however girls had significant higher DMFT values than boys ($p = 0{,}016$). ASA did not have any significant effect on dmft ($p = 0{,}471$), DMFT ($p = 0{,}252$) or dt/DT ($p = 0{,}906$) (Table 3). Type of insurance did not have significant influence on DMFT but general insurance takers showed significantly higher dmft ($p = 0{,}004$) and dt/DT values ($p = 0{,}001$). Patients with communication difficulties had significantly higher dmft ($p = 0{,}004$), DMFT ($p = 0{,}019$), and dt/DT ($p < 0{,}001$) (Table 3).

In the group of patients under 6 years of age, 13.8% ($n = 33$) had ECC type 1, 65.8% ($n = 158$) ECC type 2 and 20,4% ($n = 49$) ECC type 3 (Fig. 3). There was no significant impact of biological gender ($p = 0{,}338$), anamnestic history ($p = 0{,}116$), ASA ($p = 0{,}061$), insurance type ($p = 0{,}615$), or communication difficulties ($p = 0{,}108$) on ECC type (Fig. 3).

The mean dt/DT increased in the first 3 years of life (about 6.00–12.00), forming a plateau until the 6th year of life, decreasing until the age of nine (to about 9.00), reaching the highest value (about 15.00) from age of 9 to 13 and finally from age 13 decreased again (to about 10.00) (Table 3 and Fig. 4). This description illustrates the advantages of the mixed dt/DT very well. In the first 4 years of life, values were almost identical because patients do not yet have many fillings or missing teeth, therefore dmft is also slightly higher than dt/DT. From age 4 until the onset

Table 2 Distribution of general medical health data of the enrolled patients in total, age groups and gender, in percent and assigned to number of cases

			Anamnestic History/ Indication for General Anesthesia				ASA-Classification		
			HU	MD/PD	GD	MD/PD+GD	ASA1	ASA2	ASA3
n / %	Total		179/ 52,6	39/ 11,5	86/ 25,3	36/ 10,6	177/ 52,1	117/ 34,4	46/ 13,5
	Age	1-5	159/ 46,8	14/ 4,1	56/ 16,5	9/ 2,6	152/ 44,7	69/ 20,3	17/ 5,0
		6-12	20/ 5,9	19/ 5,6	26/ 7,6	15/ 4,4	25/ 7,4	35/ 10,3	20/ 5,9
		13+	0/ 0,0	6/ 1,8	4/ 1,2	12/ 3,5	0/ 0,0	13/ 3,8	9/ 2,6
	Gender	Female	72/ 21,2	12/ 3,5	40/ 11,8	17/ 5,0	70/ 20,6	52/ 15,3	19/ 5,6
		Male	107/ 31,5	27/ 7,9	46/ 13,5	19/ 5,6	107/ 31,5	65/ 19,1	27/ 7,9

HU: healthy and non-cooperative; MD/PD: mental disability and/or physical disability; GD: general diseases; MD/PD + GD: mental disability and/or physical disability together with general diseases

Statistical significances are marked in red

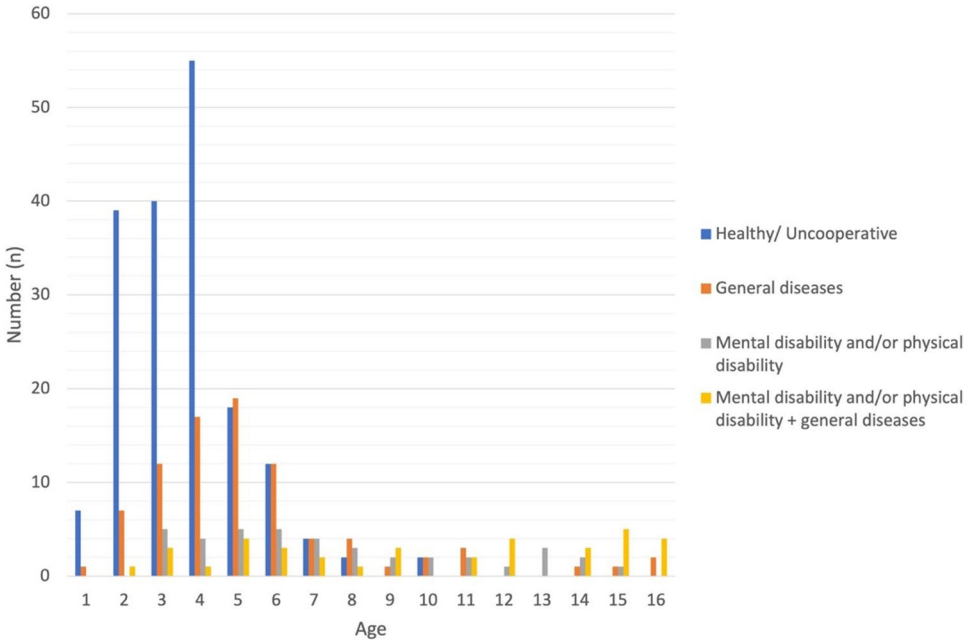

Fig. 1 Age distribution of groups according to anamnestic history, assigned to number of cases

of the mixed dentition at age of 6, the dmft value was higher than the mixed dt/DT because of filled or missing primary teeth. In mixed dentition, need for treatment according to the mixed dt/DT was always higher than dmft and DMFT. At ages 6 to 8, carious permanent teeth are not included in the dmft, and at ages up to 12, remaining carious primary teeth are not included in the DMFT. At ages 12 to 13 and 14 to 16, DMFT was higher than the mixed dt/DT because of filled and missing permanent teeth. At age 13 to 14 years, the DMFT is almost identical or minimally lower than mixed dt/DT because of the presence of primary teeth still present and carious in this age group.

Treatment data

The most, namely 88.8% ($n = 302$) of treatments were combined restorative-surgical treatments, 9.7% ($n = 33$) were restorative only and 1.5% ($n = 5$) surgical only.

A total of 2539 fillings were placed, corresponding to an mean of 7.47 ± 4.65 fillings per patient. The maximum value was 29 fillings per patient (Table 4).

A total of 1472 teeth were extracted, corresponding to an mean of 4.33 ± 3.24 extractions per patient. The maximum value was 18 extractions per patient. Two steel crowns were placed and 3 endodontic treatments were performed

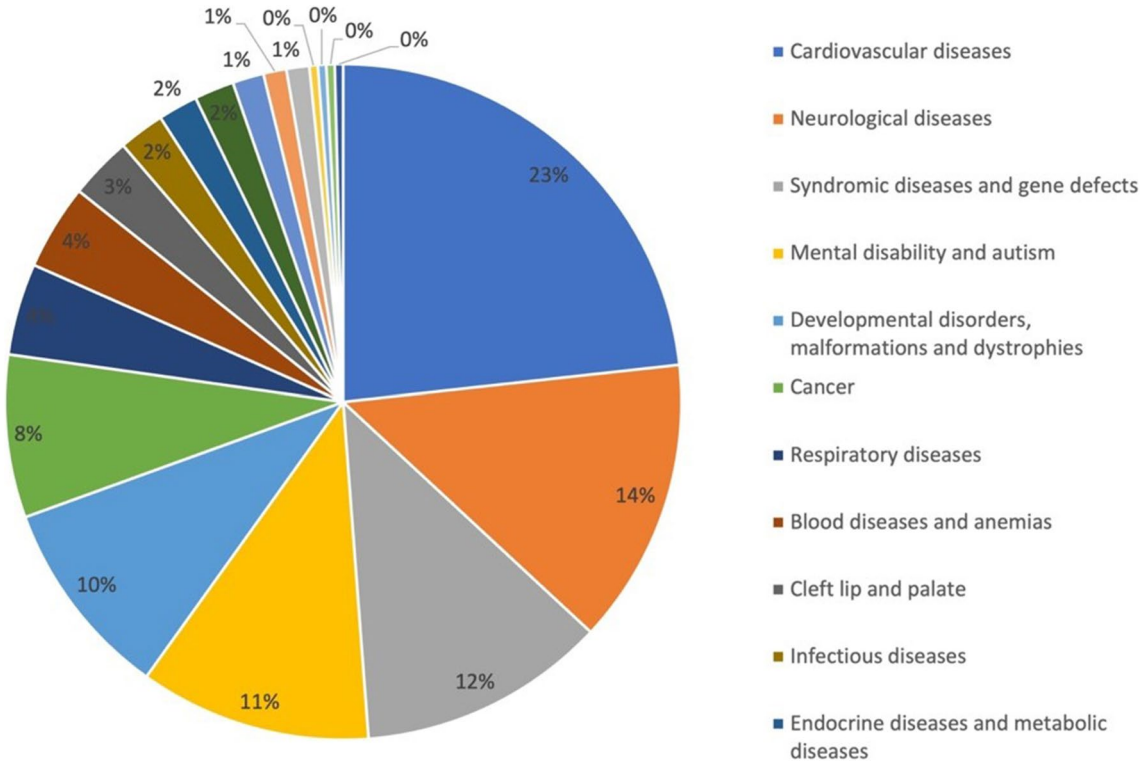

Fig. 2 Distribution of all recorded diseases in the present population

Table 3 Mean dmft, DMFT and dt/DT in total, age groups, gender, ASA groups, health insurance types and patients with and without communication difficulties

	Total			Age			Gender		ASA-Classification			Health Insurance		Communication difficulties	
	Min.	Max.	∅	1-5	6-12	13+	Female	Male	ASA1	ASA2	ASA3	General	Private	No	Yes
dt/DT	1	24	10,79 ±4,273	10,75 ±3,983	10,70 ±4,061	11,45 ±7,288	10,94 ±4,264	10,67 ±4,286	10,86 ±3,965	10,66 ±4,443	10,83 ±5,008	10,94 ±4,249	7,40 ±3,376	10,45 ±4,169	13,47 ±4,190
dmft	0	20	10,95 ±4,118	11,16 ±4,091	10,11 ±4,156		10,71 ±4,138	11,13 ±4,106	11,13 ±4,076	10,45 ±4,135	11,71 ±4,298	11,11 ±4,096	7,86 ±3,371	10,72 ±4,077	12,97 ±3,987
d	0	20	10,22 ±4,102	10,53 ±4,080	8,93 ±3,972		9,85 ±4,062	10,48 ±4,122	10,48 ±4,153	9,63 ±3,949	10,71 ±4,248	10,40 ±4,033	6,64 ±3,954	10,05 ±4,058	11,70 ±4,260
m	0	14	0,51 ±1,631	0,41 ±1,340	0,93 ±2,477		0,66 ±2,111	0,41 ±1,169	0,41 ±1,426	0,69 ±2,033	0,50 ±1,063	0,52 ±1,663	0,29 ±0,726	0,48 ±1,525	0,80 ±2,384
f	0	7	0,15 ±0,680	0,13 ±0,665	0,25 ±0,739		0,16 ±0,670	0,15 ±0,690	0,12 ±0,542	0,12 ±0,523	0,50 ±1,560	0,13 ±0,559	0,64 ±1,865	0,16 ±0,705	0,10 ±0,403
DMFT	0	26	10,09 ±7,885		8,22 ±6,543	12,05 ±8,807	13,39 ±8,045	7,89 ±7,095	8,75 ±6,397	12,53 ±8,859	8,23 ±6,914	10,23 ±7,92	4	8,84 ±7,733	15,88 ±6,058
D	0	24	8,89 ±6,523		7,17 ±4,840	10,68 ±7,618	11,06 ±6,053	7,44 ±6,530	8,50 ±6,137	11,05 ±7,299	7,09 ±5,520	9,02 ±6,53	3	7,54 ±5,909	15,13 ±5,817
M	0	11	0,91 ±2,234		0,87 ±2,564	0,95 ±1,889	1,89 ±3,123	0,26 ±0,984	0,25 ±0,500	0,95 ±2,013	1,00 ±2,619	0,93 ±2,25	0	0,95 ±2,391	0,75 ±1,389
F	0	4	0,29 ±0,895		0,17 ±0,491	0,41 ±1,182	0,44 ±1,042	0,19 ±0,786	0	0,53 ±1,264	0,14 ±0,468	0,27 ±0,89	1	0,35 ±0,978	0

Statistical significances are marked in red

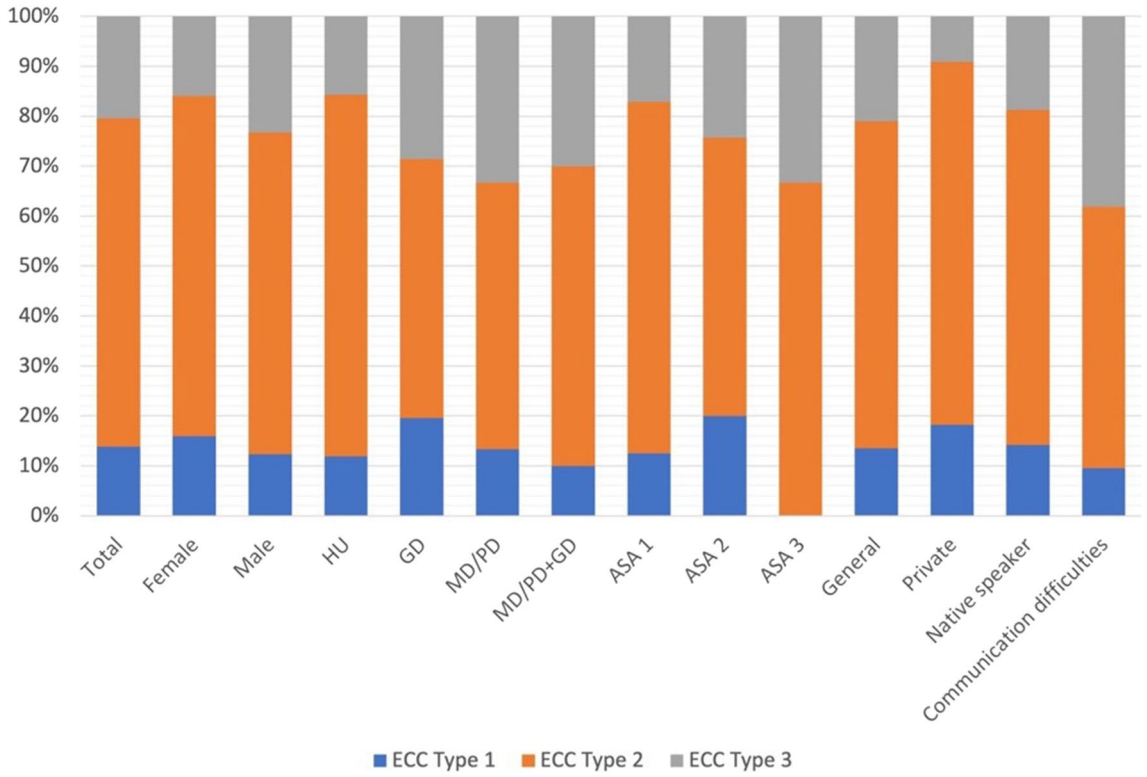

Fig. 3 ECC distribution in gender, groups according to anamnestic history, ASA groups, health insurance types and patients with and without communication difficulties, in percent (HU: healthy and non-cooperative; GD: general diseases; MD/PD: mental disability and/or physical disability; MD/PD + GD: mental disability and/or physical disability together with general diseases)

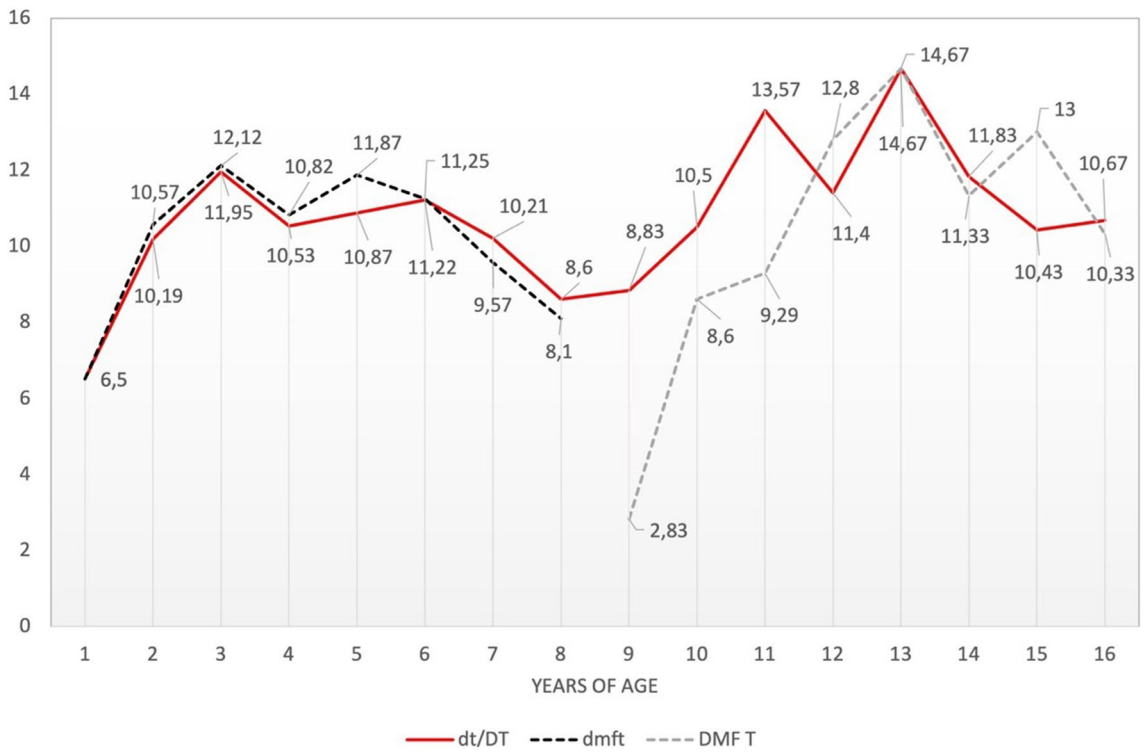

Fig. 4 Mean mixed dt/DT, dmft and DMFT over the years of age

Table 4 Number and percentage of performed dental treatments, complications, and other treatment related data in the present population

		Total	Minimum per patient	Maximum per patient	∅	Number of Patients (*n*)	Percentage (%)
Fillings		2539	0	29	7,47 ± 4,657	333	97,9
Extractions		1472	0	18	4,33 ± 3,241	307	90,3
Steel crowns		2	0	1	0,01 ± 0,077	2	0,6
Endodontic treatments		3	0	3	0,01 ± 0,163	1	0,3
Pulp openings		188	0	12	0,55 ± 0,617	58	17,1
Professional tooth cleanings						98	28,8
Intubation complications						1	0,3
Difficult drying						6	1,8
Intubation type	Nasal					236	69,4
	Oral					98	28,8
	Tracheostoma					1	0,3
	Unknown					5	1,5
Anesthesia duration (min)			40	435	170,24 ± 53,018		
Post-treatment-bleeding						1	0,3
Discharge against med. advice						36	10,6
Follow-up						41	12,0
Repeated treatment	0					318	93,5
	1					19	5,6
	> 1					3	0,9

in total. Professional tooth cleanings were performed in 98 cases (28.8%) (Table 4).

Regarding complications during treatment, 1.8% ($n = 6$) of the patients experienced difficult drying due to saliva and blood. In one case, intubation was complicated.

At least one pulp was opened during treatment in only 17.1% ($n = 58$) of the patients (Table 4).

The majority of the patients (69.4%; $n = 236$) patients were intubated nasally. Until 2013, only oral intubation was practiced. The general medical health status according to ASA did not have any significant effect on this ($p = 0{,}137$). From 2015 onwards, nasal intubation was almost the only type of intubation. The mean duration of anesthesia was 170.24 ± 53.01 min and was not significantly affected by ASA ($p = 0{,}474$).

Post-treatment-bleeding was reported in only one case. 10.6% ($n = 36$) were discharged on the day of treatment against medical advice. Only 12% ($n = 41$) appeared for follow-up within 3 months after treatment (Table 4).

Most of the patients (93.5%; $n = 318$) did not require any repeated treatment under general anesthesia (Table 4). Even if the need for repeated treatments under general anesthesia was very low, it was significantly affected by ASA. All patients who needed a further dental rehabilitation were disabled or ill ($p < 0{,}001$).

The higher ASA was, the smaller was the mean number of extractions ($p = 0{,}002$). Even if there was no significance, in contrast to extractions, the mean number of fillings increased with higher ASA ($p = 0{,}408$). Furthermore, the number of extracted teeth was significantly higher for general insurance takers, as for private insurance takers ($p = 0{,}002$). Insurance type did not influence the number of fillings ($p = 0{,}416$). Patients with communication difficulties received significantly more fillings, than native speakers ($p = 0{,}013$) not having any significant effect on the number of extractions ($p = 0{,}392$) (Fig. 5).

Discussion

The present study includes dental treatments under general anesthesia in healthy, disabled and chronically diseased children as well as adolescents over more than 10 years. This observation period makes it one of the extensive studies in this research field in the German-speaking world. Most studies were over 2–8 years [5, 6, 26-29] with the exception of two studies similar to ours [18, 30]. Studies from other European countries or non-European countries vary strongly in their observation periods [3, 17, 31, 32]. The number of cases is also varying strongly in the literature, regarding studies dealing with the present topic [3, 5, 6, 16, 18, 26-30, 32-34]. The long-term period of the present study allows us to review the evolution and success of a large part of performed dental rehabilitations under general anesthesia in our department until today. In addition, a wide age range, namely all patients under 18 were included. This enabled

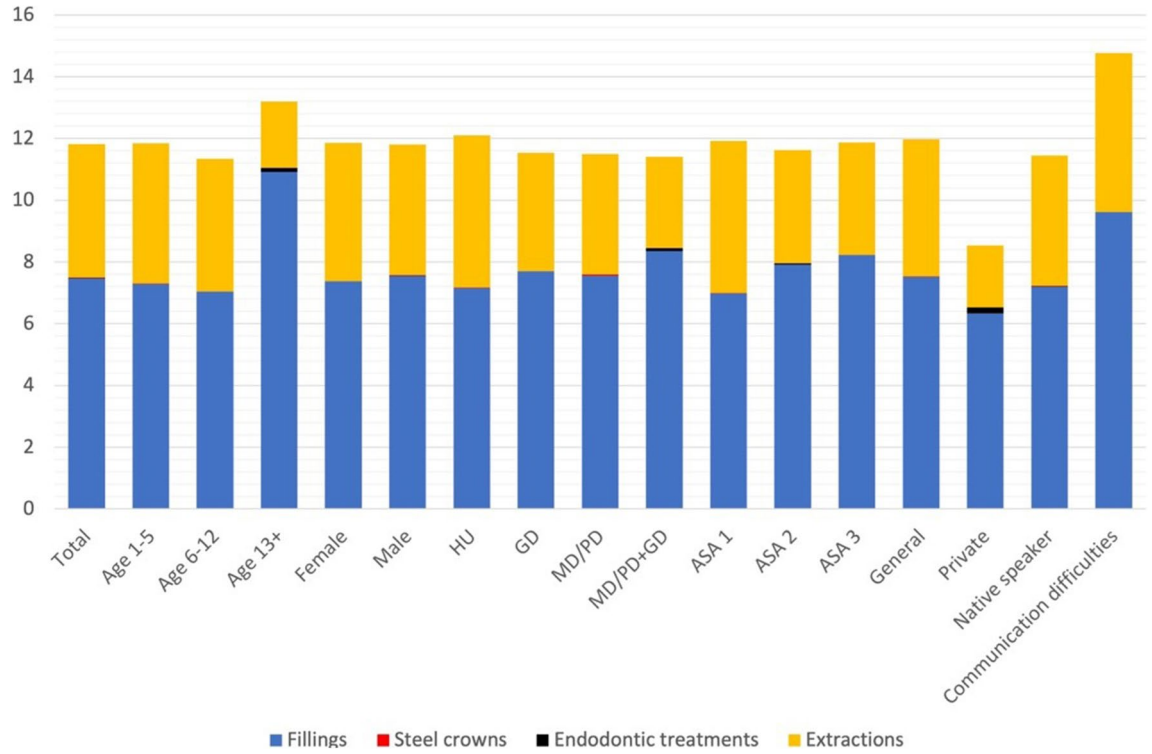

Fig. 5 Mean number of performed dental treatments in age groups, gender, groups according to anamnestic history, ASA groups, health insurance types and patients with and without communication difficulties (HU: healthy and non-cooperative; GD: general diseases; MD/PD: mental disability and/or physical disability; MD/PD + GD: mental disability and/or physical disability together with general diseases)

us to characterize patient needs and their properties in all relevant age groups. There are many studies referring either to children [3, 4, 16, 26, 29, 32] or to adults only [6, 18, 27, 30] but also some refer to children and adolescents, similar to the present study [5, 16, 28, 31].

To ensure a precise detection of clinical need for dental treatment for each patient, the present study introduced the mixed dt/DT index in addition to the WHO recommended indices dmft and DMFT [23, 24, 35]. By adding up all decayed teeth in one patient independently whether they are primary teeth or permanent teeth, the mixed dt/DT gives us a direct assessment of dental treatment needs and the extent of rehabilitation. Since every decayed tooth can cause pain and infection beside other severe consequences, every decayed tooth must be treated necessarily. This suggests that the mixed dt/DT is probably the most important clinical survey at the initial visit for patients with mixed dentition needing dental rehabilitations under general anesthesia. The indices dmft and DMFT, counting all sufficient fillings and missing teeth, lose much importance in these cases and might even falsify the diagnostic survey. Rather, dmft and DMFT complicate the diagnostic survey, in particular in the mixed dentition, as they consider primary and permanent dentition separately [35]. There are actually no studies dealing with this problem. Furthermore, a few studies used a mixed dmft/DMFT for school children or counted decayed primary or permanent teeth separately [5, 31]. The mixed dt/DT is precise in all age groups, easy to use, and therefore, should be considered as standard value in dental treatments of patients with mixed dentition under general anesthesia. Given the severely limited selection process for these treatments and the long waiting times at our hospital, it may help to prioritize patients and shorten the process.

Nevertheless, the present study regarded the dmft and DMFT for reasons of standardization and comparability. Comparing our values with the German population, the present study mainly considered results of the current Epidemiological Studies Accompanying Group Prophylaxis (DAJ study), dealing with oral health trends in children by using results from epidemiological surveys accompanying group prophylaxis in Germany [1]. In addition, the results of the Fifth German Oral Health Study (DMS V) were reflected [13]. Due to currently very low caries prevalence in German children and strong polarization of the disease into high-risk groups, the dmft and DMFT are less expressive in assessing these high-risk groups. Therefore, the Significant Caries Index (SiC) separately measuring the 33,3% of patients with highest caries experience, and the Specific Affected Caries Index (SaC), which is even more specific, were introduced [1, 36]. In addition to dmft and DMFT, the present study

compared the caries values with SiC and SaC, as the present patient population belonged predominantly in the high caries risk group.

In the DAJ study, the 3-year-olds showed an mean dmft of 0.48, a SiC of 1.47 and a SaC of 3.57. The mean dmft of 3-year-olds in the present study was 12.12, being several times higher than all values of the DAJ study. The mean dmft of 6- to 7-year-olds in the present study was 10.21 to 11.25, being also several times higher than a 1.73 dmft, a 4.84 SiC and a 3.97 SaC in the DAJ study. The mean values of the 12-year-olds in the DAJ study, a 0.4 DMFT, a 1.33 SiC and a 2.07 SaC almost match those of the DMS V with a 0.5 DMFT and 1.4 SiC. The mean value of 12-year-olds in the present study was a 12.8 DMFT, which is also significantly higher [1, 13]. Unfortunately, these two German epidemiological oral health studies did not include patients aged 13 to 18 years. Compared to other studies, mainly focusing on dental treatments under general anesthesia in children and adolescents with or without disabilities, the mean caries experience in the present study was almost in line in all age groups [5, 19, 37, 38]. Patients requiring dental treatment under general anesthesia apparently have significantly more untreated caries than already high-risk groups from epidemiological studies [1, 13] and, therefore, can be considered independent of the general population.

In the present study, age did not significantly influence the caries experience or the need for treatment. In the present study, the dmft, DMFT and mixed dt/DT were high in all age groups. While in other studies, the caries values were higher in younger patients [5, 31, 37]. In the literature, children and adolescents with diseases or disabilities are more affected by caries and gingivitis than the general population [8-10]. Remarkably in the present study, there was no significant correlation between general medical health status and caries, in contrast to epidemiological studies dealing with oral health in non-healthy children in general [8-10]. The situation is different for gingivitis, where the results showed a statistically significant influence of the general health status on severe gingivitis, which is consistent with the literature. In our population, caries was independent of the general health status, as almost all patients requiring dental rehabilitation under general anesthesia in our department suffered from a very poor oral health. Indepently if they were disabled or not, the entire population was a high-risk group for tooth decay. This is in accordance with other studies designed like ours [5]. Consistent with other studies, in the present study, there were generally no severe differences in caries experience and treatment needs between boys and girls [13, 37], but in contrast to other studies, in the present study, girls had significantly higher DMFT values than boys [13, 37]. In the present population, girls had earlier more permanent teeth than boys and, therefore, more caries affected permanent teeth compared to boys, still having more primary teeth in the DMFT age group. Regarding the mixed dt/DT, no significant difference between boys and girls could be found, confirming this assumption. Patients with general health insurance and patients with communication difficulties had statistically significantly higher dt/DT and dmft values compared to privately insured patients and native speakers. Patients with communication difficulties even had statistically significantly higher DMFT values than native speakers. Our results are in line with literature, showing that socioeconomic and patient-specific factors such as lower family income, lower education levels, type of insurance or communication difficulties can be associated with poor oral hygiene, unbalanced diet and poor access to dental care leading to poor oral health [3, 11-15, 39]. Insurance type did not have a significant impact on DMFT in the present study, possibly because there was only one private insured person in the DMFT age groups, being too low for significant effects.

In the present study, every child under 6 years of age had ECC. The most common type was ECC type 2, the so-called nursing bottle syndrome affecting the upper incisors, caused by consumption of sugary drinks via feeding bottles [25]. In the present study, ECC type 3 and ECC type 1 were less frequent. This distribution is different in other studies [5, 26]. In the present study, over 85% of children under 6 years of age were classified as at least ECC type 2, indicating that preschool children in our patient population are highly affected by extensive caries, which is in line with the high need for treatment in this age group. Seventy percent of the patients in the present study were under 6 years of age, implying that untreated ECC is the most common reason for dental rehabilitation in our clinic. The literature states that general health status and socioeconomic factors influence the prevalence of ECC [11, 39]. However, based on our specific high-risk caries patient population, statistically significant effects of general health status and socioeconomic circumstances in particular on ECC were not recorded.

In the present study, the most frequently performed procedures were placement of composite fillings, followed by tooth extractions and professional tooth cleanings. Stainless steel crowns and endodontic treatments played a minor role, consistent with literature [5, 32, 34]. Tooth destruction involving the pulp is the main indication for extraction under general anesthesia. This is because endodontic procedures under general anesthesia are technically demanding and time-consuming. In addition, normally several treatment sessions are needed to achieve optimal results. Nevertheless, studies show that single-visit endodontic treatments under general anesthesia are really promising for success and therefore should receive more attention [40-42] in order to avoid extraction of permanent teeth and to give every patient equal access to dental treatment.

There was no statistically significant effect of age and gender on the dental treatments performed, even though descriptively, the mean number of extractions was lower, and the number of fillings was higher with increasing age. The reason for this is that restoring permanent teeth with fillings was attempted more frequently than with primary teeth, being rather extracted from a certain point of decay. Our results are in accordance with the current literature [5, 32]. The mean number of extractions decreased significantly with increasing ASA in the present study. This is because the majority of non-healthy children were at school age and already had more permanent teeth, being not as severely affected by caries in relation to primary teeth, possibly already missing primary teeth at the time of treatment. Accordingly, the higher the ASA, the higher was the mean number of fillings, although this was not statistically significant. Influence of ASA varies in literature, although more fillings are often associated with more extractions, as there is a greater need for treatment in non-healthy patients in general [28, 34]. The mean number of extractions was significantly higher among those with general insurance than a private one. As mentioned above, the patients with general insurance had poorer oral health, in particular the degree of destruction per tooth was also higher, consistent with literature [3, 11-15, 39]. Patients with communication difficulties had statistically significantly higher mean number of fillings than native speakers, being in accordance with literature [28]. They had poorer oral health overall, resulting in a high need for treatment. This is also consistent with literature [3, 11-15, 39].

The type of intubation was not influenced statistically by any factor. Nasal intubation is currently the usual airway for dental procedures under general anesthesia and has a low complication rate [16, 32]. There was only one case of intubation complication in all patients. Fortunately, there were only 1,8% complications, related to difficulties of drying due to saliva and gingivitis. There were no serious complications during and after treatment, only one case of post-treatment-bleeding. Our results are consistent with the literature. Therefore, the risk of complications in dental rehabilitations under general anesthesia can be considered as minimal [16, 43-45].

In the present study, cardiovascular diseases, neurological diseases, syndromic diseases, mental disability, and autism were the most represented diseases among non-healthy patients, being mainly in line with other European studies in this field of research [5, 32]. Most of non-healthy patients had several diseases simultaneously. To get a good overview of distribution of diseases themselves, they were counted independently of the patient.

More than 90% of children and adolescents treated did not need any repeated treatment under general anesthesia. The few patients requiring repeated treatments under general anesthesia were all non-healthy, which is statistically significant in the present study and consistent with the literature [26]. Unfortunately, less than 20% showed up for post treatment or general follow-up. This follow-up compliance in the present study was significantly below that reported in literature, although it is also small in general [19, 26, 46]. It is unknown if the patients oral health is stable until now. In the present study, healthy patients, making up the largest proportion in the youngest age group, were almost absent in older age groups, being consistent with literature [34]. Possibly, they have become cooperative with age and do not need treatment under general anesthesia anymore. Generally, successful treatment can be assumed. Nevertheless, a functioning recall system is essential to prove the success of rehabilitations and to avoid repeated treatment under general anesthesia [19, 26]. Therefore, the recall system in our department should be improved.

Unfortunately, more than half of the patients treated under general anesthesia were healthy, but non-cooperative. Considering that over 46% of them were under six years of age and almost absent in the older age groups, behavioral factors like non-cooperativeness and non-compliance along with ECC is the biggest failure in the present population and should be addressed. Although general anesthesia can be safely administered, dental treatments under general anesthesia in these children should be avoided through behavioral management. There are several studies addressing this issue in literature, showing success in healthy and even mentally retarded children without any medication [47-49]. When quick action is needed, behavioral management is probably not appropriate. Therefore, alternatives should be considered such as minimal or moderate sedation with benzodiazepines or nitrous oxide. Dental anxiety in children can be reduced by this technique successfully [50], even if enterally administered benzodiazepines limit the sedation duration to about 30 min [16]. Although mortality and morbidity are low in general anesthesia and sedation, they are somewhat lower with minimal and moderate sedation [44, 45, 51]. Nitrous oxide in particular is extremely safe with almost no systemic physiologic effects. Due to this fact, it is the agent of choice for dental sedation in healthy and non-healthy patients [52, 53]. Minimal and moderate sedation does not require an anesthesist and can be used under office conditions. Furthermore, all treatments, e.g., endodontic treatments, can be performed regularly, in contrast to general anesthesia. In summary, the aim should be checking and treating these children through pre-school without general anesthesia.

The limits of this study were defined by the fact that it was designed retrospectively. Therefore, study data was not systematically collected for special questions, but rather, study questions were dependent on the data situation. Due to inadequate documentation, in particular in the first years of observation, a certain loss of information was unavoidable.

In addition, no subsequent patient surveys were conducted. Considering the importance of this research topic, prospective studies should be designed.

Conclusions

In our enrolled patients, need for dental treatment under general anesthesia was high, independent of general health status, demographical and other patient-specific factors. Nevertheless, the selection process for these treatments is strongly restricted. Non-cooperativeness and non-compliance in young healthy children along untreated ECC are the main indications for dental general anesthesia in our department. Reducing these cases, focus on behavioral management and alternatives are important, creating more treatment capacities for children needing dental treatment under general anesthesia due to their medical conditions. Finally, our results have shown that implementation of the mixed dt/DT index ensures an accurate determination of clinical treatment needs. It should be used as standard assessment to prioritize and to improve the dental treatment procedure.

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Author contributions M.P.G. planned the study. T.K. and M.P.G conducted the study and defined inclusion and exclusion criteria. T.K. conducted the data collection.

M.P.G., T.K., M.H., S.R., J.N. analyzed and interpreted the data. T.K. and M.P.G. were major contributors in writing the manuscript. All authors edited and reviewed the draft manuscript and read and approved the final manuscript.

Data Availability The dataset used and analyzed in the present study is available from the corresponding author upon reasonable request.

Declarations

Ethics approval This study was approved by the Ethics Committee of the Saarland Medical Association (289/21).

Consent to participate As this study was designed as retrospective analysis of anonymized data, formal consent was not required.

Conflict of interests Tilman Kries, Stefan Rupf, Matthias Hannig, Jusef Naim and Madline P. Gund declare no conflict of interests.

References

1. Schmoeckel J et al (2021) Oral health trends in children: results from the epidemiological surveys accompanying group prophylaxis in Germany. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz 64(7):772–781
2. Benelli K et al (2022) Pattern of caries lesions and oral health-related quality of life throughout early childhood: a birth cohort study. Eur J Oral Sci 130(5):e12889
3. Weninger A et al (2022) Risk indicators and treatment needs of children 2–5 years of age receiving dental treatment under general anesthesia in Saskatchewan. Dent J (Basel) 10(1):8
4. Baghdadi ZD, Jbara S, Muhajarine N (2021) Children and parents perspectives on children's dental treatment under general anesthesia: a narratology from Saskatoon, Canada. Eur Arch Paediatr Dent 22(4):725–737
5. Schulz-Weidner N et al (2022) Dental treatment under general anesthesia in pre-school children and schoolchildren with special healthcare needs: a comparative retrospective study. J Clin Med 11(9):2613
6. Schnabl D et al (2021) Medical diagnoses, mode of residence, and dental treatment demand under general anesthesia in special needs adults in Innsbruck, Austria. A retrospective breakdown of four and a half years. Healthcare (Basel) 9(3):279
7. Hempel E et al (2015) Oral health status of students with and without disabilities in Erfurt, Germany. Gesundheitswesen 77(4):263–268
8. Ali HM et al (2017) Presence of plaque, gingivitis and caries in Sudanese children with congenital heart defects. Clin Oral Investig 21(4):1299–1307
9. Jaber MA (2011) Dental caries experience, oral health status and treatment needs of dental patients with autism. J Appl Oral Sci 19(3):212–217
10. Schulte AG, Schmidt P (2021) Oral health in persons with disability in Germany-an overview of the literature. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz 64(7):793–801
11. dos Santos Junior VE et al (2014) Early childhood caries and its relationship with perinatal, socioeconomic and nutritional risks: a cross-sectional study. BMC Oral Health 14:47
12. Lopes ABS et al (2022) Longitudinal evaluation of determinants of the clinical consequences of untreated dental caries in early childhood. Community Dent Oral Epidemiol 50(2):91–98
13. Jordan AR, Micheelis W (eds) (2016) Fünfte Deutsche Mundgesundheitsstudie (DMS V). IDZ-Materialienreihe, Bd. 35, ed. I.D.Z. Zahnärzte. Deutscher Zahnärzte Verlag DZV: Köln. 617
14. Lampert T et al (2019) Gesundheitliche ungleichheiten bei kindern und jugendlichen in Deutschland – zeitliche entwicklung und trends der KiGGS-studie. J Health Monit 4(1):16–40
15. McCullough ML et al (2022) Association of socioeconomic and geographic factors with diet quality in US adults. JAMA Netw Open 5(6):e2216406
16. Campbell RL et al (2018) Pediatric dental surgery under general anesthesia: non-cooperative children. Anesth Prog 65(4):225–230
17. Dougherty N (2009) The dental patient with special needs: a review of indications for treatment under general anesthesia. Spec Care Dentist 29(1):17–20
18. Schnabl D et al (2019) Dental treatment under general anesthesia in adults with special needs at the University Hospital of Dental Prosthetics and Restorative Dentistry of Innsbruck, Austria: a retrospective study of 12 years. Clin Oral Investig 23(11):4157–4162
19. El Batawi HY (2014) Factors affecting clinical outcome following treatment of early childhood caries under general anaesthesia: a two-year follow-up. Eur Arch Paediatr Dent 15(3):183–189
20. Doyle DJ, Goyal A, Garmon EH (2022) American Society of Anesthesiologists Classification. In: StatPearls. StatPearls Publishing. Copyright © 2022, StatPearls Publishing LLC., Treasure Island (FL)
21. Hocevar LA, Fitzgerald BM (2022) American Society of Anesthesiologists Staging. In: StatPearls. StatPearls Publishing. Copyright © 2022, StatPearls Publishing LLC., Treasure Island (FL)
22. Klein H, Palmer CE (1938) Studies on dental caries: V. familial resemblance in the caries experience of siblings. Public Health Rep (1896–1970) 53(31):1353–1364
23. Moradi G et al (2019) Evaluation of oral health status based on the decayed, Missing and Filled Teeth (DMFT) Index. Iran J Public Health 48(11):2050–2057

24. Radic M et al (2015) Presentation of DMFT/dmft Index in Croatia and Europe. Acta Stomatol Croat 49(4):275–284
25. Wyne AH (1999) Early childhood caries: nomenclature and case definition. Commun Dent Oral Epidemiol 27(5):313–315
26. König T et al (2020) Retrospective study on risk factors for repeated dental treatment of children under general anaesthesia. Eur J Paediatr Dent 21(3):183–186
27. Maes MS et al (2022) Risk factors for repeated general anesthesia for dental treatment of adult patients with intellectual and/or physical disabilities. Clin Oral Investig 26(2):1695–1700
28. Schnabl D et al (2020) Is dental general anaesthesia in children an outdated concept? A retrospective analysis. Eur J Paediatr Dent 21(4):283–286
29. Boukhobza S et al (2021) Changes in oral health-related quality of life among Austrian preschool children following dental treatment under general anaesthesia. Clin Oral Investig 25(5):2821–2826
30. Jockusch J et al (2021) Outpatient, dental care of adult vulnerable patients under general anaesthesia-a retrospective evaluation of need for treatment and dental follow-up care. Clin Oral Investig 25(4):2407–2417
31. Grindefjord M et al (2018) Dental treatment and caries prevention preceding treatment under general anaesthesia in healthy children and adolescents: a retrospective cohort study. Eur Arch Paediatr Dent 19(2):99–105
32. Pecci-Lloret MP et al (2021) Dental treatments under general anesthesia on children with special health care needs enrolled in the Spanish dental care program. J Clin Med 10(2):182
33. Choi J, Doh RM (2021) Dental treatment under general anesthesia for patients with severe disabilities. J Dent Anesth Pain Med 21(2):87–98
34. Sevekar S, Jha MN, Avanti A (2021) Characteristics and comparison of dental treatment under general anesthesia in healthy children and children with special healthcare needs: a retrospective study. Int J Clin Pediatr Dent 14(Suppl 2):S157-s161
35. Jordan RA et al (2014) The fifth german oral health study (Funfte Deutsche Mundgesundheitsstudie, DMS V) - rationale, design, and methods. BMC Oral Health 14:161
36. Schmoeckel J et al (2019) Introducing a specific term to present caries experience in populations with low caries prevalence: Specific Affected Caries Index (SaC). Caries Res 53(5):527–531
37. Chen CY et al (2014) Oral health status of children with special health care needs receiving dental treatment under general anesthesia at the dental clinic of Taipei Veterans General Hospital in Taiwan. J Chin Med Assoc 77(4):198–202
38. Wang N, Zhao YM (2018) Retrospective study of dental treatment under general anesthesia of 62 disabled children and adolescents. Beijing Da Xue Xue Bao Yi Xue Ban 50(2):293–299
39. Lebrun-Harris LA et al (2021) Oral health among children and youth with special health care needs. Pediatrics 148(2)
40. Alsaleh I et al (2012) Is endodontic treatment performed under general anaesthesia technically acceptable? Clin Oral Investig 16(6):1599–1606
41. Chung SH et al (2019) Periapical healing in single-visit endodontics under general anesthesia in special needs patients. J Endod 45(2):116–122
42. Linas N et al (2019) Conservative and endodontic treatment performed under general anesthesia: a discussion of protocols and outcomes. Spec Care Dentist 39(5):453–463
43. Bennett JD, Kramer KJ, Bosack RC (2015) How safe is deep sedation or general anesthesia while providing dental care? J Am Dent Assoc 146(9):705–708
44. Caputo AC (2009) Providing deep sedation and general anesthesia for patients with special needs in the dental office-based setting. Spec Care Dentist 29(1):26–30
45. El-Mowafy A et al (2019) Mortality and morbidity in office-based general anesthesia for dentistry in Ontario. Anesth Prog 66(3):141–150
46. Michels S, Bansal N, Greene C (2021) Impact of follow-up visit timing recommendations after dental rehabilitation under general anesthesia. Pediatr Dent 43(6):470–474
47. Armfield JM, Heaton LJ (2013) Management of fear and anxiety in the dental clinic: a review. Aust Dent J 58(4):390–407; quiz 53
48. Delli K et al (2013) Management of children with autism spectrum disorder in the dental setting: concerns, behavioural approaches and recommendations. Med Oral Patol Oral Cir Bucal 18(6):e862–e868
49. Thosar NR et al (2022) Effectiveness of two different behavior modification techniques for anxiety reduction in children. Cureus 14(8):e28141
50. Guney SE et al (2018) Dental anxiety and oral health-related quality of life in children following dental rehabilitation under general anesthesia or intravenous sedation: a prospective cross-sectional study. Niger J Clin Pract 21(10):1304–1310
51. Inverso G et al (2016) Complications of moderate sedation versus deep sedation/general anesthesia for adolescent patients undergoing third molar extraction. J Oral Maxillofac Surg 74(3):474–479
52. Becker DE, Rosenberg M (2008) Nitrous oxide and the inhalation anesthetics. Anesth Prog 55(4):124–30; quiz 131–2
53. Galeotti A et al (2016) Inhalation conscious sedation with nitrous oxide and oxygen as alternative to general anesthesia in precooperative, fearful, and disabled pediatric dental patients: a large survey on 688 working sessions. Biomed Res Int 2016:7289310