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PATIENT SAFETY IN ANESTHESIA (SJ BRULL AND JR RENEW, SECTION EDITORS)

The Path to Safety in Dental Anesthesia

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Abstract

Purpose of Review Sedation and anesthesia in dental office–based settings are specialty practices that have unfortunately been riddled with bad outcomes and near misses. Both healthcare professionals and the public usually receive information about these events from media reports and seldom from any other comprehensive sources. This review will identify potential sources of reliable data in which to guide practice and training.

Recent Findings Recent investigations into the training of practitioners and auxiliaries, the dental office–based setting, and regulations governing dental sedation and dental anesthesia practice have highlighted a glaring lack of reliable data in which to pinpoint root causes and potential solutions.

Summary The path forward to increased safety may exist in awareness of the issues and potential closed-claims analysis of outcomes. Because of the lack of systemic and ongoing data collection for mainly private practice and dental office–based sedation and anesthesia settings, insurance and closed-claims data investigations may be the most reliable source for current morbidity and mortality examinations.

Keywords Dental anesthesia · Patient safety · Pediatric dentistry · Pediatric anesthesia · Anesthesia education · Sedation guidelines · Dental sedation guidelines · Dental anesthesia care team · Anesthetist operator model · Single operator model

Introduction

The distinct specialties of dentistry and anesthesiology have been intertwined since the first successful public demonstration of ether anesthesia on October 16th, 1846, at the Massachusetts General Hospital by dentist William T.G. Morton. Although both fields have developed significantly since then, the practice of general anesthesia and sedation for dental procedures by both specialties remains popular and common in the USA, Canada, and other parts of the world.

A great deal of controversy still exists as to the standard of care and best practice models in dental sedation. Sedation and anesthesiology in medical practice are governed by extensive regulations, require standardized training, and follow thoroughly reviewed guidelines. Curiously, dentistry does not follow the same models in either the office or hospital-based settings, despite being regulated by state and provincial dental regulatory bodies. Due to long-engrained differences in training, remote clinical settings, lack of standard protocols, and differing requirements by each state's dental boards, the provision of sedation and anesthesia is often practiced in settings that might be considered risky by those in the medical field.

Both clean and sterile dental procedures, extensive and invasive in scope, are performed regularly on a variety of patients ranging from young pediatric patients to patients with complex special healthcare needs and an increasing geriatric patient population. Various methods of anesthesia including parenteral and enteral sedation, inhalation sedation, deep sedation, and general anesthesia are administered in dental offices or clinics. Commensurate with the increase in demands, dentistry has also seen advances in the utilization of sedation techniques, monitoring requirements, advanced training, and practice regulation, although not at

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the same rate as seen in the medical field. This has led to the creation of separate, sometimes contradictory, and often overlapping guidelines for adult and pediatric patients and subsequently increased scrutiny on the incidence of morbidity and mortality in dental anesthesia. While it appears that in some practice models common in dentistry, there may be higher morbidity and mortality, accurate data is limited and difficult to obtain [1]. This article will review both the advances made in dental sedation and anesthesia as well as the continued opportunities for improvement.

Growth in Dental Office–Based Sedation and Anesthesia

The number and complexity of procedures being performed in dental office–based settings have increased significantly [2]. Recent investigations have estimated procedures utilizing deep sedation and general anesthesia in oral surgery offices alone number 2.8 million annually [3]. The popularity of more invasive surgeries with immediate dental cosmetic results has risen dramatically, and in pediatrics, parents and caregivers prefer sedation to the trauma of restraint. In 2016, Patel et al. noted that protective stabilization (i.e., papoose board) was the least accepted advanced dental treatment strategy by parents of children undergoing dental procedures [4]. Additionally, with the increasing utilization of moderate sedation and general anesthesia among pediatric dentists, caregivers are more reliant upon these modalities in the course of restorative dental treatment [5]. Other recent surveys have demonstrated up to a 240% increase in utilization of both ambulatory surgery centers (ASCs) and hospital-based operating rooms for pediatric dental care under general anesthesia from 2007–2017 [6].

Training and Education in Dentistry

As a result, dentists, anesthesiologists, and other physicians have increased their efforts to improve training and safety of dental anesthesia. The 2018 Commission on Dental Accreditation (CODA) standards for post-doctoral residency training in pediatric dentistry were revised and, for the first time, had requirements with regard to the number and type of sedation each pediatric dental resident needed to perform for accreditation (Table 1). Similar numerical thresholds to determine basic competency are published by CODA for dental anesthesiology, advanced periodontology, and oral and maxillofacial surgery.

The demand for general anesthesia has increased partly because of the high failure rate (30–40%) of enteral sedation techniques. Each State in the USA (and province in Canada) has different requirements for dental sedation and anesthesia. Restrictions exist in routes of administration of the medication (enteral versus parenteral), type and number of medications, and targeted depth of sedation. Unfortunately, this can lead to the sedatives used for enteral sedation that are sometimes employed in dosages and combinations beyond their intended depth leading to deeper levels of sedation.

More challenging patients are seeking dental care and are often referred to academic centers. Dentists and trainees are increasingly encountering patients presenting with anxiety, hypertension, developmental delay, overactive gag reflexes, local anesthesia failures, a fear of needles, or claustrophobia who need sedation and general anesthesia [7]. Additionally, the market pressures of the patient and parental expectations of amnesia or "pain-free" and "injection-less" dental treatment have further driven the need for sedation and anesthesia services [8]. A 2016 study went as far as to propose that "Moderate sedation with midazolam (OR 2.9, 95%CI 1.2–6.9) or midazolam/ketamine (OR 4.3, 95%CI 1.6–11.4) improved children's future behavior" [9].

Table 1 Overall length of post-doctoral specialty dental training and moderate sedation level training

Dentist practitioner	Overall length of training	Sedation- or anesthesia-related training by CODA	Clinical competency and practice permit
Hospital-based general practice resident	1–2 years	70 h of hospital-based anesthesia rotation	Certificate of completion of Graduate Practice Residency and applicable U.S. state dental board permitting for minimal/moderate sedation
Pediatric dentist	2 years	-20 patient experiences with N_2O -50 patient experiences with other sedatives (25 as primary operator/sedationist) -4 consecutive weeks of a rotation in general anesthesia	Pediatric dentistry advanced training certificate and applicable U.S. state dental board permitting for minimal/moderate sedation
Periodontist	3 years	Clinical competency in enteral and parenteral moderate sedation to standards outlined in ADA Guidelines -20 live patient experiences 60 h of didactic instruction	Periodontology specialty advanced training certificate and applicable U.S. state dental board permitting for minimal/moderate sedation

Pre-doctoral Dental Training in Sedation and Anesthesia

The typical 4-year dental school graduate in the USA is competent in delivering intra-oral local anesthesia as part of the American Dental Association's (ADA) CODA minimal educational standards and some form of pain and anxiety control to dental patients. Often, the most accessible and common form of anxiolysis for general dentist practitioners to learn is minimal sedation such as inhalation sedation with nitrous oxide or the prescription of a single dose of an oral sedative medication. They typically receive didactic and clinical instruction in various techniques of intra-oral local anesthesia administration, including relevant pharmacology, physiology, anatomy, and potential for complications. Recognition of complications, including local anesthesia systemic toxicity (LAST), paresthesias associated with administration, or inadvertent intravascular injection with local anesthesia is a critical component of pre-doctoral education. They are exposed to the concept of moderate sedation and the principles of deep sedation and general anesthesia. Some students in dental education institutions receive initial clinical instruction through a peer-to-peer model of intra-oral local anesthesia administration. This model seldom extends to nitrous oxide inhalation sedation, although a few institutions have implemented this type of experiential learning [10]. Many states use age-based delineation for use in the pediatric population, with 12 years of age being a common age marker. Although pre-doctoral dental students may not receive clinical training in the various modes of sedation and anesthesia, the ADA strongly encourages continued instruction in minimal and moderate sedation techniques utilized in dentistry [11].

Specific to dentists at both the pre-doctoral and post-doctoral levels is an emphasis *upon the route of administration of sedative medications*. Unlike in hospital-based or ambulatory surgery settings, general dentists in the office-based or clinic-based setting generally do not have the resources, personnel, or training to routinely administer parenteral medications. Most importantly, within the practice of dentistry within the U.S., the most recent "2016 ADA Guidelines for the Teaching of Pain Control and Sedation for Dentists and Dental Students" explicitly define the dose of enteral sedative medications intended for minimal sedation to not exceed the *maximum recommended dose* (MRD). The MRD of any drug intended for minimal sedation is defined as.

> *Maximum recommended dose (MRD)*: the maximum [U.S. Food and Drug Administration]-recommended dose of a drug, as printed in FDA-approved labeling, for unmonitored home use.

Additionally, the ADA directs a specific method in which enteral minimal sedation can be administered by general dentists and some specialists with no other sedation or anesthesia training. The guidelines specify that.

> *Dosing for minimal sedation via the enteral route* – minimal sedation may be achieved by the administration of a drug, either singly or in divided doses, by the enteral route to achieve the desired clinical effect, not to exceed the maximum recommended dose (MRD).

Instruction in minimal enteral sedation, as defined by the ADA, must be 16 course hours in length, and learners must either administer sedative medications under faculty supervision or observe patients undergoing enteral minimal sedation. Nitrous oxide inhalation sedation in combination with enteral sedation techniques can be considered minimal, moderate, or deep sedation depending on a patient's clinical presentation.

Dentist General Practitioner Moderate Sedation Training

General dentists and dental specialists who do not receive sedation or anesthesia training in their post-doctoral program may provide parental moderate sedation after matriculation from a 4-year accredited dental school by participating in and successfully completing a 60-h, 20 live patient continuing education course outlined by the *2016 ADA Guidelines*. The types of dentist practitioners without formal or structured moderate sedation training are.

- General dentists
- General dentists with advanced education in general dentistry (AEGD)
- General dentists in hospital-based general practice residencies (GPR)
- Endodontists
- Dental public health specialists
- Orofacial pain specialists
- Oral medicine specialists
- Oral and maxillofacial pathologists
- Oral and maxillofacial radiologists
- Orthodontic and dentofacial orthopedic specialists
- Prosthodontists

In these continuing education courses for dentists, basic physiologic monitoring, pharmacology related to moderate sedation, venipuncture, and rescue from unintended deeper levels of sedation are stressed. Some, but not all, courses require certification in advanced cardiac life support (ACLS). Upon successful completion and demonstration of competency, practitioners are eligible for parenteral

moderate sedation permitting by their respective state dental boards. To satisfy these requirements for a pediatric population, candidates are required to submit clinical evidence or documentation of age-appropriate cases (dependent on state regulations) or didactic/clinical hours from a post-doctoral residency program. For example, a recent regulation established in California states that permit application and renewal require documentation of at least 20 moderate sedation cases in a "pediatric endorsement" process stated below.

> California Code of Regulations § 1043.1. Permit Application Requirements.
> (e) If the applicant wishes to administer or order the administration of moderate sedation to patients under thirteen years of age, the applicant shall apply for a pediatric endorsement to their moderate sedation permit as set forth in Section 1043.8.1 and receive approval from the Board.

It should be noted that patient safety and crisis management as curriculum items are not specifically addressed in ADA educational standards. Concepts of team communication, early identification, and "mock drills" are not routinely used in a pre-doctoral or continuing education-level curriculum. There is no requirement for discussion of outcomes or morbidity and mortality from dental procedures and/or complications from sedatives or anesthetics involved in dental care.

Post-doctoral Training in Sedation and Anesthesia

Some ADA-recognized and CODA-accredited advanced education post-doctoral programs, otherwise known as dental specialty training programs, incorporate differing levels of sedation and anesthesia training. Specific accredited post-doctoral residencies require that graduating residents be competent in the delivery of advanced forms of sedation and anesthesia in dental settings. For some programs, such as pediatric dentistry and periodontics, competency must be attained in moderate sedation. Post-doctoral programs in dental anesthesiology and oral and maxillofacial surgery require competency in deep sedation and general anesthesia. *However, attainment of these levels of clinical competencies for a specific dental specialty's intended treatment population is highly variable not only from one specialty to the next, but also from different institutions.* This variability not only extends between specialties but between states as well. Minimum training requirements for various practitioners allowed to provide dental anesthesia and sedation are listed in Table 2

Safety Vulnerabilities of Dental Sedation and Anesthesia

Since dental office–based sedation and anesthesia have been long considered the prototypical non-operating room anesthesia (NORA) venue, the common dental practice models have endured many of the same techniques without change. The requisite safety assurances and quality process practices that are present in hospitals, accredited surgery centers (ASC), or physician-based office settings are not incorporated or utilized with regularity in dental office settings. The fundamental systems such as reserve oxygen sources, backup power generation, trained auxiliary personnel, ACLS or PALS certification, or ready access to consultant practitioners are absent. When coupling these factors with findings from a 2017 closed-claims examination performed by Woodward et al. on non-operating room settings, the dental office–based setting is at high risk for potential patient harm [3].

The submitted closed-claims number of dental office–based sedations and anesthetics may be disproportionally small compared to the volume of procedures performed in hospital-based settings, yet the characteristics of NORA complications raise concern. From recent reports, the metrics examined for NORA medical procedures indicate that safety and quality are trailing far behind the traditional hospital operating room setting [12•]. Cases resulting in patient death performed outside of hospitals were more likely to involve patients under the age of 16 years, lie within an American Society of Anesthesiologists (ASA) physical status category of 3–5, and involve monitored anesthesia care (MAC) and natural airway anesthesia [13]. A landmark study by Bennett et al. found that respiratory complications compromised the bulk of malpractice claims with a frequency that exceeded that of hospital operating room settings in children undergoing anesthesia out of the OR [14•]. In dental office–based sedation or general, these risks may be magnified because the airway is shared, there may be noise interference from intra-oral suctions and dental handpieces, and access to immediate resuscitative support and trained personnel is minimal. Airway rescue can be complicated by an operating dentist and dental materials continually occupying the upper airway space and impeded by oral isolation devices (rubber dams, combination suction–tongue retraction devices, dental appliances), and saliva, blood, or irrigation.

A common practice in dentistry is the single-operator model where the dentist provides both deep sedation or general anesthesia simultaneously with the procedure itself [15]. The accompanying dental personnel involved with these types of procedures are dental assistants or auxiliaries with minimal to no formal medical training in sedation or anesthesia, particularly with pediatrics. These dental auxiliaries

Table 2 Training of dental and medical providers in deep sedation/general anesthesia

Deep sedation and general anesthesia provider type	Permitted to function independent of supervision by anesthesiologist	Minimum duration of program required for eligibility of certification	Minimum number of deep sedation or general anesthesia Cases	Minimum number of pediatric cases	Definition of pediatric patient (years)	Minimum number of special healthcare needs cases	National examination/ specialty board certification
Certified anesthesiology assistant	No	24–30 consecutive months	400 GA	50	0–18	Not required	National Commission for Certification of Anesthesiologist Assistants
Certified registered nurse anesthetist	In some areas	24–30 consecutive months	25 DS, 400 GA	<2yrs: 10 2–12: 30	12 or younger	Not required	National Board of Certification and Recertification for Nurse Anesthetists
Dentist anesthesiologist	N/A	36 consecutive months	800	125	7 or younger	75	American Dental Board of Anesthesiology
Physician anesthesiologist	N/A	48 consecutive months (including clinical base year)	N/A	100	12 or younger	N/A	American Board of Anesthesiology
Pediatric anesthesiologist	N/A	12 consecutive months following 48-month physician residency program	N/A	N/A	N/A	N/A	American Board of Anesthesiology–Subspecialty Board Examination in Pediatric Anesthesiology
Oral and maxillofacial surgeon	N/A	20 weeks hospital O.R. rotation supplemented with deep sedation/GA for oral surgical procedures during course of 48-month training	300	50	18 or younger	Not required	American Board of Oral and Maxillofacial Surgery
***Dental sedation assistant (utilized in oral surgery "team" model of care) ***Not licensed to independently administer medications or diagnose. Must work in conjunction with licensed oral surgeon permitted to administer general anesthesia	No	36 h of self-directed study, followed by 2-h, computer-based examination Prerequisites: be employed by a member of the American Association of Oral and Maxillofacial Surgeons for 6 months, Basic Life Support certified	N/A	N/A	N/A	N/A	Dental Anesthesia Assistant National Certification Examination (DAANCE), American Association of Oral and Maxillofacial Surgeons

*** dental sedation

have no consistent training in sedation or anesthesia, including recognition of complications or resuscitative care, such as pediatric or adult advanced life support. Some dental assistants may receive training in patient monitoring and may even be asked to administer medications intravenously, although their training is not commensurate with that of a registered nurse [16, 17].

Models of Sedation and Anesthesia Practice

It is currently unknown how many sedations are performed for dental procedures in the office-based setting. A recent study has demonstrated that both moderate sedation and general anesthesia are effective at extending caries-free time in children with early childhood caries (ECC) or severe early childhood caries (S-ECC), with a slight advantage given to dental treatment under general anesthesia [18]. However, unlike hospital-based care, there is currently no reliable way to track the number and types of procedures being performed in the dental office–based settings. Data for adult sedation and anesthesia for dental procedures is scant as well, and there remains no reliable method to track the number or types of elective procedures performed in the dental office–based settings.

In pediatric dentistry practice in the USA, oral moderate sedation with single or multiple agents is by far the most popular treatment modality utilized for intentional moderate sedation. Various regimens, including combinations of opioid analgesics and/or nitrous oxide inhalation sedation, are commonly practiced [19]. For decades, orally administered meperidine, along with benzodiazepines or antihistamines, has been common techniques. Oral codeine was another frequently used medication, but after a U.S. FDA warning against its use in children under age 12 [20], its use has all but disappeared from pediatric use. Chloral hydrate has found a similar fate. As an alternative, some practitioners are using oral morphine to provide analgesia and sedation during pediatric dental procedures [21]. It should be noted that various states, hospitals, or healthcare entities may limit a provider's treatment by pre-defining either the type and/or number of medications (including nitrous oxide and local anesthetic) that may be used for various levels of sedation.

Recommendations outlined in the updated 2019 American Academy of Pediatrics/American Academy of Pediatric Dentistry's (AAP/AAPD) "Guidelines for Monitoring and Management of Pediatric Patients During and After Sedation for Diagnostic and Therapeutic Procedures: An Update" recommend a dentist utilize at least a dental assistant when utilizing minimal or moderate sedation on children. The dental assistant, while performing the regular "interruptible" duties of dental care, must also be able to assist in monitoring and, if needed, assist in resuscitation from a sedation-related event [22]. The current 2019 AAP/AAPD Guidelines were updated to recommend a separate anesthesia provider (dentist or physician anesthesiologists, physician, certified registered nurse anesthetists, or an additional oral surgeon) when administering deep sedation or general anesthesia to pediatric patients in dental settings [23••].

Patient monitoring has also been addressed by the AAP/AAPD Guidelines and reinforced with educational standards. Consistent with CODA and ASA standards, a conscious patient is monitored with a pulse oximeter, an intermittent non-invasive blood pressure cuff, a pre-tracheal stethoscope, and/or capnography. These pediatric guidelines also spell out the requirement of a cardiac defibrillator and requisite training in its use for deep sedation or general anesthesia. Table 3 summarizes the typical practice models of dentist practitioners of varying specialties along with commonly used sedative or anesthesia agents.

As previously mentioned, the model of sedation and anesthesia delivery within dental office–based settings most associated with the practice of oral and maxillofacial surgery, namely, the operator-sedationist, single-operator, or operator-anesthetist model, is specially addressed in the 2019 AAP/AAPD Guidelines. The American Association of Oral and Maxillofacial Surgeons (AAOMS) refers to this unique practice as a team model of anesthesia. This differs from the American Society of Anesthesiologist's definition of the team model in that the only licensed anesthesia provider is also the proceduralist involved in the conduct of the surgery. Dental auxiliaries with various levels of familiarity in sedation/anesthesia monitoring and care are present, but not trained in advanced resuscitation. Consistent with CODA training standards, these guidelines recommend that at least two other dental assistants are required, with one dental assistant dedicated solely to patient monitoring, while another dental assistant assists the surgeon in the procedure. As previously mentioned, the base level of resuscitation training for these dental assistants is basic life support. Because of the depth of sedation and anesthesia achieved, along with the lack of assurance that the dental assistants monitoring the patient have adequate training and knowledge to intervene and alert a surgeon in appropriate circumstances, the authors of the guidelines advocate for a separate, trained anesthesia provider when dental surgery involved pediatric patients [23••]. These guidelines and a recent case report acknowledge that one person, no matter how skilled, cannot adequately perform multiple simultaneous critical tasks, while guaranteeing that safety remains a top priority. Deep sedation and general anesthesia delivery in remote locations require the same level of qualified personnel as do patients in any other modal setting [24••]. In 2023, one attempt to codify these guidelines into practice regulation has been proposed in the New Hampshire legislature, and its incorporation into dental practice is as of this publication still undetermined [1].

Table 3 Dentist practitioner types and typical models of sedation/anesthesia practice

Dentist practitioner type	Sedation/anesthesia practice model	Sedative/anesthesia agents commonly employed	Required patient vital signs monitoring
General dentist or dentist specialist without advanced moderate sedation training	Minimal sedation practiced as an operator-sedationist	Nitrous oxide inhalation sedation, single oral sedative up to maximum recommended U.S. Food & Drug Administration maximum recommended dose, or a combination of both	For adults, no requirement for specific monitoring. 2019 AAP/AAPD Guidelines recommend additional monitoring for moderate sedation when oral sedatives are combined with nitrous oxide greater than 50% of inhalation concentration
General dentist or dentist specialist with advanced moderate sedation training (pediatric dentists and periodontists)	Minimal to moderate sedation using oral and intravenous moderate sedation agents as an operator-sedationist and a dental assistant	Oral and intravenous benzodiazepines, intravenous opioids, oral and intravenous antihistamines, also used in combination with nitrous oxide Adjunctive medications—steroids, NSAIDs, antiemetics, or antisialogogues	Pulse oximetry, continual non-invasive blood pressure measurement, and capnography
Dentist anesthesiologist	Deep sedation/ general anesthesia, oral or nasotracheal intubation, or natural airway as a separate anesthesia provider	Inhalation and intravenous general anesthetics along with typical adjuncts	Pulse oximetry, continual blood pressure measurements, respiratory rate, capnography, electrocardiogram, external temperature (if MH* triggering agents utilized)
Oral and maxillofacial surgeon	Deep sedation/ general anesthesia with natural airway as an operator-anesthetist and dental assistants	Intravenous benzodiazepines, intravenous opioids, ketamine, propofol, with or without nitrous oxide inhalation sedation Adjunctive medications—steroids, NSAIDs, antiemetics, or antisialogogues	Pulse oximetry, continual blood pressure measurements, respiratory rate, capnography, electrocardiogram, external temperature (if MH* triggering agents are used)

Inconsistencies continue to exist with the operator-sedationist model with personnel and levels of training. Attempts to standardize training for oral surgery dental assistants and programs such as the Dental Anesthesia Assistant National Certification Examination (DAANCE) [15] have been promoted. However, this curriculum is largely self-regulated and minimally adopted in the workforce. Even with this additional certification, most dental assistants cannot intervene with life-saving measures that include the establishment of intravenous access, independent administration of any medications, or diagnosis of complications [25].

Addressing the Demands for Increased Safety in the Dental Office–Based Setting

In 1998, the UK instituted sweeping changes mandated by the UK's General Dental Council on the practice of sedation and general anesthesia in dental settings after a series of patient deaths. New practice parameters entitled "Maintaining Standards: Guidance for Dentists on Professional and Personal Conduct." Training recommendations and course syllabi for pediatric and adult patients have been published and updated by groups such as the Independent Expert Group on Training and Standards for Sedation in Dentistry (IEGTSSD). Currently, in the UK, deep sedation and general anesthesia for dental procedures are reserved for hospital-based settings.

The landmark publication by Coté et al. in 2000 reviewed a series of cases involving death or other significant sequelae occurring in children undergoing sedation. The out-of-hospital settings contributed greatly to a lack of timely resuscitation and failure to use appropriate interventions and monitoring[23]. Of the cases examined, 20/60 pediatric patients suffered death or significant neurologic injury in dental offices, and in the majority, anesthesia and sedation were provided by the dentist or oral surgeon performing the procedure (see previous section on operator-anesthetist model). In addition, the study highlighted the use of multiple sedative agents and the lack of trained personnel able to provide skilled rescue interventions. In 2013, Lee et al. examined trends in death associated with pediatric dental treatment involving sedation and similarly concluded that office-based settings appeared to be a major risk factor for mortality. The authors acknowledged that access to data was a major limiting factor in forming associations and conclusions [17]. Bennett et al. reported on mortality and morbidity of anesthesia provided by oral maxillofacial surgeons by reviewing the records of a national malpractice carrier that insures 80% of practicing oral and maxillofacial surgeons in the U.S. They concluded that approximately 1 patient death or brain injury occurred per every 348,602 anesthetic procedures, with 1 such event occurring every 6 weeks [14•]. Unfortunately, investigations into root cause analysis and contributing factors in dental settings have been negligible.

In 2016, Ganzberg involved in sedation and anesthesia education referred to the writings of Atul Gawande, who popularized checklists in his book, *A Checklist Manifesto.* Gawande distinguishes between errors of ignorance (mistakes we make because we do not know enough) and errors of ineptitude (mistakes we make because we do not make proper use of what we do know). Mishaps in medicine and many other fields, he writes, "are really about the second of these errors." The application of commercial aviation concepts of safety and procedural checklists to dental office–based sedation and anesthesia providers is advocated by Ganzberg. Moreover, checklists do not exist as a "de facto" indication of safety, but instead, they must be strictly adhered to, as deviations have resulted in catastrophes in both the airline industry and in medicine/dentistry [26]. The duration, depth, and breadth of sedation and anesthesia training, coupled with a lack of specific error mitigation, may be contributing factors weighing heavily into the safety of dental office–based sedation and anesthetics.

The UK's National Institute for Health and Care Excellence (NICE) published additional guidelines in 2015 for the sedation of children and young people which demonstrated adherence to most of the accepted forms of practice and monitoring used at that time in other healthcare arenas [27]. From the NICE examination of dental sedation practices in 2015, typical agents found in moderate sedation practice in dental settings outside of a hospital included the use of nitrous oxide, benzodiazepines, propofol, and ketamine. Of all the respondents, approximately 75% utilized pulse oximetry, and 50% utilized non-invasive blood pressure measurement. Yet capnography, as reported by NICE, was only utilized by 3.7% of the respondents. The inconsistent utilization of standard monitoring in office-based environments has led to a demand for the improvement of policy and guideline statements by leading professional societies, such as the aforementioned revision of the 2019 AAP/AAPD Monitoring Guidelines. The recently recognized specialty of dental anesthesiology has also produced a considerable portion of the recent literature examining processes and protocols for safe practices, including a Parameters of Care document that specifically mandates a separate provider for deep sedation and general anesthesia in dental settings, contemporary monitoring standards, and training [28]. Despite these advances, data collection on complications and outcomes remains an enigma due to the "cottage" nature of private dental/oral surgery offices. Many of the lessons from mishaps and misadventures are not revealed for critical examination due to legal protections, and events are rarely disclosed in the literature as closed-claims surveys.

Scrutiny and Directives from Professional Organizations Involved in Sedation and Anesthesia

As referenced earlier, the American Society of Dentist Anesthesiologists (ASDA) has established a practice standard in which all patients, both pediatric and adult, receiving deep sedation or general anesthesia for dentistry require a separate anesthesia provider. In their 2018 Parameters of Care, ASDA stipulated that [29].

> "When deep sedation or general anesthesia is employed in a dental setting, a minimum of 3 individuals must be present: the operating dentist/surgeon, the dentist anesthesiologist, and a dental/surgical assistant (and/or another staff member who is involved in minor, interruptible tasks) who can aid in resuscitative efforts [5, 6]. The dentist anesthesiologist provider must not be simultaneously involved in the conduct of the dental procedure or surgery, unless another licensed anesthesia provider is present."

The previously mentioned 2019 AAP/AAPD Guidelines parallels this statement with a similar directive for a separate provider (anesthesiologist, other physician, nurse anesthetist, or oral surgeon) to administer deep sedation or general anesthesia, while a separate practitioner renders dental care to pediatric dental patients. The ASA has a similar statement "ASA Statement on Sedation & Anesthesia Administration in Dental Office-Based Settings from the Committee on Quality Management and Departmental Administration and approved by the ASA House of Delegates on October 25th, 2017," which was updated and amended in 2022 [28].

The American Association of Nurse Anesthesiology (AANA) also provides a similar position statement in their policy document concerning sedation and anesthesia in dental settings, from their 2017 "Dental Office Sedation and Anesthesia Care Position Statement" [30].

Practical Steps Forward in Dental Office–Based Sedation and Anesthesia Safety

Most patients, many physicians, and other referring providers are unaware of the differences in sedation as practiced in dentist offices compared to sedation practiced by the medical profession. While legislation would be ideal, the legislative process and regulatory hurdles are often fraught with special interest political lobbying. Education is critical in helping both referring physicians and patients understand the options available in dental office sedation and anesthesia. When California confronted this issue after a pediatric death in an oral surgeon's office [1, 24

> "The administration and monitoring of deep sedation or general anesthesia may vary depending on the type of procedure, the type of practitioner, the age and health of the patient, and the setting in which anesthesia is provided. Risks may vary with each specific situation. You are encouraged to explore all the options available for your child's anesthesia for their dental treatment, and consult with your dentist, family physician, or pediatrician as needed." [31]

The intent of including such language was to provide information and engage patient autonomy in the type of anesthesia model employed by dental practitioners. So far, this has been the furthest acknowledgment any current dental regulation has reached in addressing this specific topic.

Attempts at enacting legislation and imposing regulatory boundaries and practice changes have been met with limited success [32]. Strong professional political lobbies tend to protect the interests of dental practitioners practicing at a profitable status quo. Lack of available studies demonstrating the superiority of delivery models and the ethical constraints of attempting to conduct such studies are severe limitations to encouraging change in the current modes of practice. Current state reimbursement for dental sedation and anesthesia remains relatively low compared to private fees which may be partly responsible for minimal motivation in adopting practices otherwise found in medicine such as separate sedation or anesthesia providers, predictable routes of drug administration, that would increase costs. In the rare instances where dental care is performed in hospital-based settings, care is generally covered by healthcare insurance. In the private dental office setting, however, reimbursement for separate anesthesia providers is seldom covered or is minimal. The disparity between government-subsidized care and private practice fees and practice settings greatly impacts dental care and safe sedation [33].

Those who operate under the operator-sedationist or operator-anesthetist model in dentistry have recognized that their practice is under intense scrutiny. Todd et al., in a recent editorial in the *Journal of Oral & Maxillofacial Surgery*, have acknowledged that the larger professional anesthesia provider community has not been assuaged in their concerns of this mode of office-based anesthesia care and have proposed sweeping changes to their professional membership to improve safety. Current post-doctoral sedation and anesthesia training standards for oral surgeons are outlined in Table 2. The proposal includes a 5-year phase-in of DAANCE-certified assistants, a mandated simulation training program, and quarterly mock drills in adverse events after matriculation from residency and while in private practice [34]. While ambitious, the plan requires full adoption by AAOMS membership (~5500 active practicing members) [35].

Unlike medicine, there is no culture of self-assessment and examination in dentistry. Regular morbidity and mortality examinations do not occur, nor is this environment of introspection offered in pre- or post-doctoral training programs. Critical event analysis is rare and sporadic in dental training or in private dental practice. Many hospital-based care facilities, and all Accreditation Council for Graduate Medical Education (ACGME)-accredited residencies, are required to have department/division-level assessments of morbidity and mortality. Current literature demonstrates that even resident-level-led discussions led to quantifiable improvements in outcomes [36]. Identification of errors and shortcomings in communication, judgment, diagnosis, surgical or procedural technique, care utilization, or poor process and workflow are discussed in an open, non-threatening format. Currently, no mandate to provide ongoing peer review or quality process examination is established by any agency involved in dental practice, although some hospital-based training programs (dental anesthesiology, pediatric dentistry, oral and maxillofacial surgery) and dental services (general practice residency) incorporate these reviews as an integral component of hospital activity [37]. The American Dental Education Association (ADEA) has also recognized the dental profession's slow engagement with peer-review processes and has urged institutions to integrate peer-review mechanisms as a regular and ongoing item in the educational/practice milieu [38].

Closed-claims examination of dental malpractice suits is needed to provide meaningful data on practice trends that may have resulted in patient harm. Advocacy is required to begin full disclosure of data collected by indemnity carriers for the benefit of patient safety and to identify areas of improvement that may result in lowered insurance costs for practitioners. Conversely, contemporary and collated clinical outcome examinations may validate current practices, including the oral surgery team model. Various factors have driven medicine's adoption of data-fortified arguments to enact change on an institutional and national level, including federal healthcare funding, and quality and safety mandates. Unfortunately, with dentistry enjoying reimbursement options that often incorporate fee-for-service practice models, the economic downward pressure on spending and liability insurance that prompt root cause analysis and closed-claims analysis in other industries are absent.

Conclusion

Informed decision-making by the patient and an understanding of the different models of sedation and anesthesia services in dental care by both patients and physicians are critical in changing practice. The awareness of varying practice models, practitioner training, support personnel, and practice settings can be evaluated by an informed patient. Unfortunately, most patients and physicians are unaware of the difference in sedation/anesthesia in the dental setting as compared to medical settings. The standards of safety in the dental setting are expected to be as high as in hospital-based care given the routine nature and frequency of patients seeking dental care. Yet incongruity exists in anesthesia care delivery models and practitioners, and this remains obfuscated in the office-based dental setting to patients. Multiple factors exist as barriers to advancing safe care practices, and forward progress is often met with resistance as institutional, educational, and regulatory bodies face both internal and external pressures. Nevertheless, current clinical education paradigms clearly lack sufficient transparency and peer-review analysis that could contribute to meaningful examination and possible change in practices. From the other end of the professional spectrum, unbiased and complete analysis of outcomes related to malpractice claims and professional licensing administrative actions can both validate current practices and drive change in modalities that are in dispute. Independent and comprehensive data gathering on procedures, medications used, and outcomes, as practiced in many medical institutions, are critical in understanding the system-related problems and possible solutions. Additional applications of metrics used to evaluate value-based care in other out-of-the-OR settings should also be involved in the calculus of patient safety. This path forward must incorporate a more introspective, rigorous, and inclusive system of outcome review by all stakeholders to improve the safety of our dental patients.

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Data Availability No datasets were generated or analyzed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

1. New Hampshire Senate Bill 147. February 2023. Accessed online at: https://legiscan.com/NH/bill/SB147/2023
2. Hicks CG, Jones JE, Saxen MA, Maupome G, Sanders BJ, Walker LA, Weddell JA, Tomlin A. Demand in pediatric dentistry for sedation and general anesthesia by dentist anesthesiologists: a survey of directors of dentist anesthesiologist and pediatric dentistry residencies. Anesth Prog. 2012;59(1):3–11. https://doi.org/10.2344/11-17.1.
3. Saxen MA, Tom JW, Mason KP. Advancing the Safe delivery of office-based dental anesthesia and sedation. Anesthesiol Clin. 2019;37(2):333–48. https://doi.org/10.1016/j.anclin.2019.01.003.
4. Patel M, McTigue DJ, Thikkurissy S, Fields HW. Parental attitudes toward advanced behavior guidance techniques used in pediatric dentistry. Pediatr Dent. 2016;38(1):30–6.
5. Avenetti D, Lee HH, Mehta N, Raja S, LeHew C. General anesthesia verus moderate sedation: factors affecting caregivers' decisions for children's dental treatment modality. J Dent Child. 2021;88(3):187–96.
6. Peter Douglas, Barbara Sheller, Travis Nelson, Elizabeth Velan, JoAnna M. Scott; Comparison of pediatric dentistry under general anesthesia in a surgery center vs a hospital. Anesth Prog. 2022; 69 (4): 3–8. https://doiorg.libproxy1.usc.edu/10.2344/anpr-69-02-07
7. Setty M, Montagnese TA, Baur D, Aminoshariae A, Mickel A. An analysis of moderate sedation protocols used in dental specialty programs: a retrospective observational study. J Endod. 2014;40(9):1327–31. https://doi.org/10.1016/j.joen.2014.05.015.
8. Huh YK, Montagnese TA, Harding J, Aminoshariae A, Mickel A. Assessment of patients' awareness and factors influencing patients' demands for sedation in endodontics. J Endod. 2015;41(2):182–9. https://doi.org/10.1016/j.joen.2014.10.009.
9. Antunes DE, Viana KA, Costa PS, Costa LR. Moderate sedation helps improve future behavior in pediatric dental patients - a prospective study. Braz Oral Res. 2016;30(1):1–9. https://doi.org/10.1590/1807-3107BOR-2016.VOL30.0107.
10. Crivello BJ, Reddy AA, Pazdernik VK, Davis JM. Impact of experiential learning on dental students' training in nitrous oxide inhalation sedation. J Dent Educ. 2020;84(12):1399–408. https://doi.org/10.1002/jdd.12345.
11. Guidelines for teaching pain control and sedation to dentists and dental students. American Dental Association, Adopted October 2016. Accessed November 8, 2022
12. • Keswani A, Licht B. Frameworks for value-based care in the nonoperating room setting. Curr Opin Anaesthesiol. 2022;35(4):508–13. https://doi.org/10.1097/ACO.0000000000001164. **The findings of this review may serve as a surrogate for the outcomes expected in office-based care, with an even lower expectation of elevated quality due to a lack of standardization and a lack of culture of safety in dentistry.**
13. Woodward ZG, Urman RD, Domino KB. Safety of non-operating room anesthesia: a closed claims update. Anesthesiol Clin. 2017;35(4):569–81. https://doi.org/10.1016/j.anclin.2017.07.003.
14. • Bennett JD, Kramer KJ, Bosack RC. How safe is deep sedation or general anesthesia while providing dental care? The Journal of the American Dental Association (1939). 2015;146(9):705–708. https://doi.org/10.1016/j.adaj.2015.04.005. **This study, published in the Journal of the American Dental Association, is one of the few recent publications that cite actual claims data to give an indication of the rate of significant morbidity and mortality occurring in a discipline of dental practice.**
15. Drew SJ. Oral and maxillofacial surgery team anesthesia model and anesthesia assistant training. Oral Maxillofac Surg Clin North Am. 2018;30(2):145–53. https://doi.org/10.1016/j.coms.2018.01.002.
16. Coté CJ, Notterman DA, Karl HW, Weinberg JA, McCloskey C. Adverse sedation events in pediatrics: a critical incident analysis of contributing factors. Pediatrics. 2000Apr;105(4 Pt 1):805–14. https://doi.org/10.1542/peds.105.4.805.
17. Lee HH, Milgrom P, Starks H, Burke W. Trends in death associated with pediatric dental sedation and general anesthesia. Paediatr Anaesth. 2013;23:741–6. https://doi.org/10.1111/pan.12210.
18. Burgette JM, Quiñonez RB. Cost-effectiveness of Treating severe childhood caries under general anesthesia versus conscious sedation. JDR Clin Trans Res. 2018;3(4):336–45. https://doi.org/10.1177/2380084418780712.
19. Nelson T, Wilson S, Tanbonliong T. Opioid and multi-drug pediatric dental sedation: a narrative review. J Dent Child (Chic). 2022;89(1):57–65.
20. JD Tobias, TP Green, CJ Coté, Section on anesthesiology and pain medicine, committee on drugs, Rita Agarwal, Corrie T.M. Anderson, Courtney Alan Hardy, Anita Honkanen, Mohamed A. Rehman, Kathleen Neville, Constance S. Houck, Bridgette Jones, Ian M. Paul, Janice E. Sullivan, John N. Van Den Anker Codeine: time to say "no". Pediatrics. 2016; 138 (4): e20162396. https://doi.org/10.1542/peds.2016-2396.
21. Chen N, Tanbonliong T. Comparison of two morphine-benzodiazepine-hydroxyzine combinations for the oral sedation of pediatric dental patients: a retrospective study. Pediatr Dent. 2018;40(1):43–8 (PMID: 29482682).
22. American Academy of Pediatrics, American Academy of Pediatric Dentistry, Work Group on Sedation. ,. Pediatrics (Evanston). 2006;118(6):2587–602. https://doi.org/10.1542/peds.2006-2780.
23. •• Charles J. Coté, Stephen Wilson, American ACADEMY OF PEDIATRICS, AMERICAN ACADEMY OF PEDIATRIC DENTISTRY; Guidelines for monitoring and management of pediatric patients before, during, and after sedation for diagnostic and therapeutic procedures. Pediatrics 2019; 143 (6): e20191000 https://doi.org/10.1542/peds.2019-1000. **The publication of these practice guidelines governing the practice of pediatric sedation and anesthesia directly addressed a specific practice model within dentistry which addresses concerns of the single provider model. Although the basis for the recommendation has been challenged by specific dental specialties, supporting consensus statements from other sedation and anesthesia groups have bolstered these guidelines.**
24. •• American Society of Anesthesiologists Joint statement on pediatric dental sedation: joint statement from the American Society of Anesthesiologists, the Society for Pediatric Anesthesia, the American Society of Dentist Anesthesiologists, and the Society for Pediatric Sedation regarding the use of deep sedation/general anesthesia for pediatric dental procedures using the single-provider/operator model. 2019. Accessed online on 1/23/2023 at: https://www.asahq.org/advocacy-and-asapac/advocacy-topics/office-based-anesthesia-and-dental-anesthesia/joint-statement-pediatric-dental-sedation. **An important position statement by major professional societies advocating for the utilization of a separate, qualified anesthesia provider in dental office–based deep sedation and general anesthesia practices that followed the release of the 2019 AAP/AAPD Guidelines on Sedation and Anesthesia.**

25. American Association of Oral And Maxillofacial Surgeons. Dental anesthesia assistant national certification candidate handbook. 2023. Accessed online on 1/23/2023 at: https://www.aaoms.org/docs/cont_education/daance/daance_handbook.pdf
26. Ganzberg S. Promoting a culture of safety. Anesth Prog. 2016 Spring;63(1):1–2. https://doi.org/10.2344/0003-3006-63.1.1. PMID: 26866404
27. Coulthard P, Craig D, Holden C, Robb ND, Sury M, Chopra S, Holroyd I. Current UK dental sedation practice and the 'National Institute for Health and Care Excellence' (NICE) guideline 112: sedation in children and young people. Br Dent J. 2015;218(8):E14. https://doi.org/10.1038/sj.bdj.2015.338.
28. American Society of Anesthesiologists. Statement on sedation & anesthesia administrationin dental office-based settings. 2017. Accessed on February 2021 from: https://www.asahq.org/standards-and-guidelines/statement-on-sedation--anesthesia-administration-in-dental-officebased-settings
29. American Society of Dentist Anesthesiologists: Parameters of Care Anesth Prog 2018 Fall;65(3):197–203
30. American Association of Nurse Anesthesiology. Dental office sedation and anesthesia care position statement. 2017. Last accessed on July 24th, 2023 from : https://issuu.com/aanapublishing/docs/7_-_dental_office_sedation_and_anesthesia_care?fr=sN2M0MDU2NDAxMjU
31. Dental Board of California, California Business and Professions Code, Article 4. Suspension and revocation of licenses. Last accessed online on July 25th, 2023 at: https://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=BPC&division=2.&title=&part=&chapter=4.&article=4.
32. Otto, M. What we can learn from the failed effort to pass 'Caleb's Law' in California. Sept 11, 2017. Association of Health Care Journalists. Accessed online 12/17/2022 at https://healthjournalism.org/blog/2017/09/what-we-can-learn-from-the-failed-effort-to-pass-calebs-law-in-california/
33. brahim H, Nelson T, Thikkurissy S, Xu Z, Scott J. Comparison of procedures, time and fees associated with procedural sedation and general anesthesia in a pediatric dentistry residency program. Journal of dentistry for children (Chicago, Ill). 2022;89(2):104–109
34. Todd DW, Weber CR, Krishnan DG, Egbert MA. Oral-maxillofacial surgery anesthesia team model at a crossroads safety in office-based anesthesia – lessons we can learn from aviation. J Oral Maxillofac Surg. 2021;79(9):1812–4. https://doi.org/10.1016/j.joms.2021.05.015.
35. AAOMS. (2023, January 12). About AAOMS. AAOMS.org. Retrieved August 10, 2023, from https://www.aaoms.org/about
36. Tignanelli CJ, Embree GGR, Barzin A. House staff–led interdisciplinary morbidity and mortality conference promotes systematic improvement. J Surg Res. 2017;214:124–30. https://doi.org/10.1016/j.jss.2017.02.065.
37. Friedlander AH, Perkins K, Felsenfeld AL, Graves LL, Freymiller E. Enhancement of resident competencies via participation the peer review/quality improvement processes and morbidity & mortality presentations. J Oral Maxillofac Surg. 2016;75(2):237–9. https://doi.org/10.1016/j.joms.2016.10.037.
38. Exhibit 11: ADEA position papers. Journal of dental education. 2022;86(S2):S123-S137. https://doi.org/10.1002/jdd.13056