Comparison of Anesthesia for Dental/Oral Surgery by Office-based Dentist Anesthesiologists versus Operating Room-based Physician Anesthesiologists

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Few studies have examined the practice characteristics of dentist anesthesiologists and compared them to other anesthesia providers. Using outcomes from the National Anesthesia Clinical Outcomes Registry and the Society for Ambulatory Anesthesia Clinical Outcomes Registry for dental/oral surgery procedures, we compared 7133 predominantly office-based anesthetics by dentist anesthesiologists to 106,420 predominantly operating room anesthetics performed by physician anesthesia providers. These encounters were contrasted with 34,191 previously published encounters from the practices of oral and maxillofacial surgeons. Children younger than 6 years received the greatest proportion of general anesthetic services rendered by both dentist anesthesiologists and hospital-based anesthesia providers. These general anesthesia services were primarily provided for complete dental rehabilitation for early childhood caries. Overall treatment time for complete dental rehabilitation in the office-based setting by dentist anesthesiologists was significantly shorter than comparable care provided in the hospital operating room and surgery centers. The anesthesia care provided by dentist anesthesiologists was found to be separate and distinct from anesthesia care provided by oral and maxillofacial surgeons, which was primarily administered to adults for very brief surgical procedures. Cases performed by dentist anesthesiologists and hospital-based anesthesia providers were for much younger patients and of significantly longer duration when compared with anesthesia administered by oral and maxillofacial surgeons. Despite the limited descriptive power of the current registries, office-based anesthesia rendered by dentist anesthesiologists is clearly a unique and efficient mode of anesthesia care for dentistry.

Key Words: Dentist anesthesiologist; OBA; Office-based anesthesia; Operating room; NACOR; National Anesthesia Clinical Outcomes Registry; SCOR; SAMBA Clinical Outcomes Registry; Early childhood caries; ECC; Dental rehabilitation.

Dentist anesthesiologists are unique anesthesia providers. They are the only class of anesthesia providers in dentistry who do not use the operator-anesthetist model as their primary method of delivering anesthesia care.[1] Postdoctoral residency programs in dental anesthesiology are the only accredited advanced dental education programs that focus exclusively on providing a full spectrum of anesthesia services for all types of dental procedures in both the hospital/ambulatory surgery center (ASC) operating room and dental office environment. No clinical training in dental or oral surgery is included in the dental anesthesiology residency.[2] The unique training of this class of dentists bears more resemblance to the training of medical anesthesia providers than other dental specialties, yet the literature is nearly silent regarding the nature of their clinical practice after completion of their training.[3]

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Most of what is currently known about dental office-based anesthesia is derived from the oral surgery literature. Perrott et al[4] reported on a 12-month, prospective study of outcomes of 34,191 office-based anesthetics in oral and maxillofacial surgery offices. This study, which was commissioned by the American Association of Oral and Maxillofacial Surgeons, was described as the most complete prospective study of dental outpatient anesthesia in the private practice setting; however, these results pertain only to oral surgical procedures, performed in oral surgery offices.[4] Selected practice characteristics of all US dentists holding intravenous conscious sedation or general anesthesia permits, which are required by dental boards in order for dentists to provide these services, were examined and reported by Boynes et al[3] in 2010. This survey described the training and general practices of all dentists performing sedation and anesthesia, including dentist anesthesiologists, but offered very little detail about any one class of anesthesia provider. The degree to which these studies are relevant to the practice of office-based anesthesia by dentist anesthesiologists remains unknown.

This project sought to describe general demographic and practice characteristics of dentist anesthesiologists in the United States by examining data from 2 sources: the Clinical Outcomes Registry of the Society for Ambulatory Anesthesia (SCOR) and the National Anesthesia Clinical Outcomes Registry (NACOR). SCOR is a national database that collects data from both physician and dentist anesthesiologists working outside of the hospital operating room, in ambulatory surgery centers and office-based anesthesia.[5] This registry is a web-based database, developed by the Society for Ambulatory Anesthesia (SAMBA) to allow members to track demographic and clinical outcomes. For the purposes of this study, the SCOR registry allowed us to examine demographic and clinical outcomes data that were specific to dentist anesthesiologists. NACOR, the largest clinical anesthesia registry in the United States, provides data from anesthesia performed in all locations by all providers, inside and outside of the hospital.[6] For the purposes of this study, the NACOR registry provided demographic and clinical outcomes data that were specific to dental treatment under anesthesia but rendered primarily by physician anesthesiologists and members of a medical anesthesia care team. By comparing and contrasting data taken from these sources, as well as the Perrott et al[4] study mentioned previously, we sought to determine if the practice of office-based anesthesia by dentist anesthesiologists is distinguishable from the anesthesia practices of oral surgeons and medical anesthesia providers reporting to NACOR.

METHODS

The respective Institutional Review Boards at the Indiana University and Brigham and Women's Hospital approved this project. All practitioner and patient data were deidentified prior to analysis. The study design is a secondary analysis of data collected from the SAMBA Clinical Outcomes Registry and the National Anesthesia Clinical Outcomes registry over a 4-year period, between 2010 and 2014.

A total of 8322 entries from 26 United States dentist anesthesiologists were collected from the SCOR. Members of the American Society of Dentist Anesthesiologists (ASDA) voluntarily recorded data from their practices into the SCOR database. Dentist anesthesiologists were defined as participants who met the requirements for National Uniform Claim Committee Provider Taxonomy Code 1223D0004X, which includes dentists who have successfully completed an accredited postdoctoral anesthesiology residency training program of 2 or more years' duration, in accord with the Commission on Dental Accreditation's Standards for Dental Anesthesiology Residency Programs, and/or meet the eligibility requirements for examination by the American Dental Board of Anesthesiology. Of the 8322 entries, those with missing data for American Society of Anesthesiologists (ASA) class, age, sex, case duration, anesthesia type, and/or facility type were excluded from the analysis, leaving 7133 available for the analysis.

A total of 26,568,734 records were collected by the Anesthesia Quality Institute (AQI) from NACOR from 491 reporting centers. All cases in the NACOR database that contained a Clinical Classification Score for dental surgeries were identified. Of the 151,677 dental cases, all cases assigned an ASA physical status classification greater than 4, cases not labeled as having had general anesthesia or monitored anesthetic care, and cases that had missing data for ASA class, age, sex, case duration, facility type, and/or United States regional location were excluded, leaving 106,420 cases available for the analysis.

Cases entered into NACOR were determined to be "dental cases" on the basis of diagnosis codes in the edition of the International Diagnostic Coding system (ICD-9) and procedure codes from Current Procedural Terminology (CPT). Relevant dental ICD and CPT codes were collected into a specific group, designated as Clinical Classification Code 29, and listed in the Healthcare Cost and Utilization Project (HCUP). In contrast to NACOR, the SCOR database does not collect ICD-9 diagnosis codes. Dental cases were identified in SCOR by collecting records entered by dentist anesthesiologists reporting dental-related CPT

codes. Both databases de-identify patient information but contain various data regarding patient demographics, diagnosis, procedures, billing, and providers, as well as rates of adverse events in a subset of cases.

Demographic and procedural parameters examined in both registries included facility type, CPT code, ICD-9 code (as available), gender, age, ASA physical status classification, anesthesia start time, surgery start time, surgery end time, recovery begin time, and recovery end time. The facility types included in NACOR included university hospitals, large community hospitals (more than 500 beds), medium-sized community hospitals (100–499 beds), small community hospitals (less than 100 beds), specialty hospitals, attached surgery centers, freestanding surgery centers, and "other." The facility types in SCOR included office-based setting and freestanding ambulatory surgery centers.

Statistical analysis for 2 group comparisons included unpaired t test with Welch's correction. Multiple group comparisons were analyzed with 1-way analysis of variance (ANOVA) using Bonferroni correction for post hoc analysis. All statistical analysis was performed using Prism 6.0 Statistical Analysis software (GraphPad Software, San Diego, California). All findings noted as significant are set at a level of $p < .01$.

RESULTS

Twenty-six dentist anesthesiologists participated in SCOR between January 1, 2010, and December 31, 2014, representing approximately 11% of the membership of American Society of Dentist Anesthesiologists during this time. Eighty-three percent of the participating dentist anesthesiologists were board certified by the American Dental Board of Anesthesiology. The mean number of years in practice was 19.1 years.

Ninety-one percent of the cases in the SCOR-ASDA group received anesthesia in an office, with the remainder having received anesthesia is a freestanding ASC. In contrast, 79.2% of the patients in the NACOR-DENTAL database received anesthesia in a hospital facility, 4.1% in a freestanding ASC, and the remainder in "other" environments. The mean age of patients seen by dentist anesthesiologists in the SCOR-ASDA registry (8.99 years) was younger than the NACOR dental population (11.63 years). Patients seen in the SCOR-ASDA registry were nearly all within ASA physical status classification ASA 1 and 2, with less than 2% possessing a classification of ASA 3 or higher. In contrast, 12.5% of the patients in the NACOR-DENTAL group had a physical status classification of ASA 3 or higher. There was no significant difference between the groups in gender (Table 1).

The age distribution of dental cases in both registries was remarkably similar (Figure 1a and b). Both samples displayed an initial rise around the age of 1 year, peak incidence between 5 and 6 years of age, and a return to basal levels around the age of 9. For both groups, children aged 6 years and younger comprised the largest group of patients receiving dental care (Table 2). A second, small, relatively flat peak was also noted in the NACOR-DENTAL distribution, reaching its maximum at age 17 before diminishing. This peak was not seen in the SCOR-ASDA distribution.

The average intraoperative surgical time for cases in the NACOR-DENTAL registry was 46% longer than the average intraoperative surgical time logged into the SCOR-ASDA registry. (Figure 2a; Table 3a). Figure 2b and Table 3b compare the different perioperative times for various phases of treatment for patients receiving anesthesia from dentist anesthesiologists in an office-based environment verses a freestanding ASC.

The most common diagnosis code cited in the NACOR-DENTAL registry was 521.0, unspecified dental caries. ICD-9 diagnosis codes were not included as a collected data point in the SCOR registry. The most commonly cited procedures in the NACOR-DENTAL databases was 41899, unlisted procedure for dentoalveolar structures, while the most commonly recorded code in the SCOR database was 00170, anesthesia for intraoral procedures (Table 4).

DISCUSSION

Approximately two-thirds of patients undergoing anesthesia in the NACOR database and three-quarters of patients in the SCOR-ASDA database were children younger than 6 years. For both populations, the peak number of cases occurred between age 5 and 6. Unspecified dental caries was listed as a diagnosis in 69.5% of the cases. When one corrects for the dramatic difference in size between the NACOR-DENTAL and SCOR-ASDA samples, the age distribution curves are nearly superimposable (Figure 3). Taken together, these findings provide strong evidence that dental rehabilitation of early childhood caries (ECC) represents a prominent necessity for general anesthesia by independent anesthesia providers in both the hospital and office-based environment.

ECC is an age-defined, pathological condition that describes severe, progressive dental caries occurring in the first 71 months of life. It is the most common disease of childhood in the United States, with more than 4.5 million cases developing this condition each year.[7] Not surprisingly, ECC is among the most common conditions treated by pediatric dentists and the most common

Table 1. Comparison of NACOR Dental and SCOR-ASDA Demographic Data*

	NACOR-DENTAL	*SCOR-ASDA*
Location, %		
Hospital	79.2	—
University hospital	6.0	
Large community hospital	9.9	
Medium community hospital	34.0	
Small community hospital	1.5	
Specialty hospital	21.2	
Attached surgery centers	6.4	
Freestanding surgery center	4.1	8.9
Office	16.5 ("Other")	91.0
Gender, %		
Female	45.5	48.3
Male	54.5	51.7
Physical status class, %		
ASA 1	62.7	76.0
ASA 2	24.8	22.7
ASA 3	11.2	1.3
ASA 4	1.3	—

* ASA, American Society of Anesthesiologists; ASDA, American Society of Dentist Anesthesiologists; NACOR, National Anesthesia Clinical Outcomes Registry; SCOR, Society for Ambulatory Anesthesia Clinical Outcomes Registry.

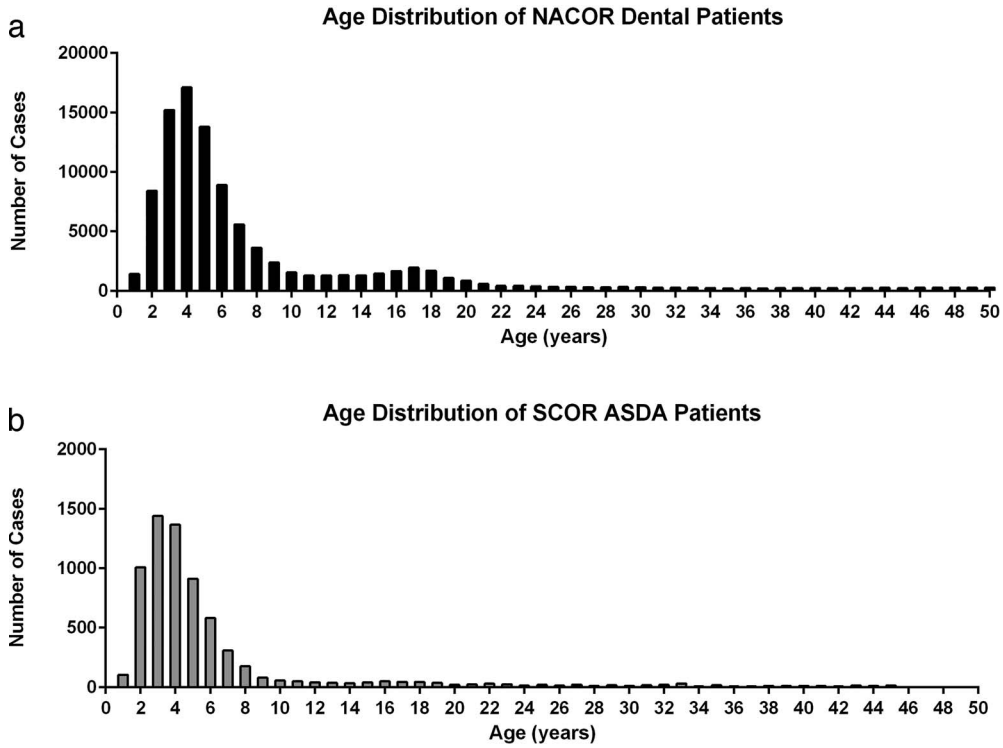

Figure 1. Most patients receiving general anesthesia from either OR anesthesia providers (a) or dentist anesthesiologists (b) are children between 2 and 6 years of age. This age range also corresponds to the ages in which early childhood caries is found.

Table 2. Pediatric Age Distribution of Dental Cases*

Age, y	*NACOR-DENTAL, %*	*SCOR-ASDA, %*
≤6	60.95	75.90
≤10	73.28	84.63
≤2	86.23	90.28
Mean ± SD	11.63 ± 15.51	8.99 ± 13.79

* NACOR-DENTAL indicates cases performed by physician anesthesiologists/anesthesia care team in hospitals, ASCs. when applicable. SCOR-ASDA indicates cases performed by dentist anesthesiologists doing office-based anesthesia.

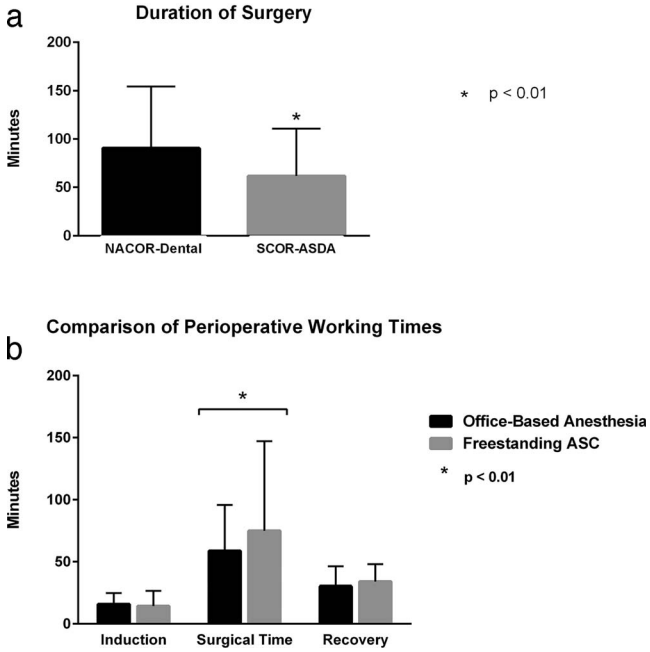

Figure 2. (a) A comparison of surgical case duration in National Anesthesia Clinical Outcomes Registry–DENTAL and Society for Ambulatory Anesthesia Clinical Outcomes Registry (SAMBA-SCOR) registries. Surgical duration is defined as the difference between surgical start and stop times, in minutes. (b) A comparison of ambulatory surgery center and office-based venues with regard to induction time, perioperative time, and recovery time. All cases were performed by the dentist anesthesiologists in the SAMBA-SCOR registry.

diagnosis of pediatric dentists treating patients in a hospital under general anesthesia.[8] A 2012 Technical Report by the Pediatric Oral Health Policy and Research Center concluded that general anesthesia is essential for providing "medically necessary care to those children who may be cognitively immature, highly anxious or fearful, have special needs, or are medically-compromised and unable to receive treatment in a traditional settings."[9] The 2012 American Dental Association Survey on Pediatric Dental Practice Characteristics reported that 59.5% of pediatric dentists in the United States use a hospital operating room or ambulatory surgery center to treat children under general anesthesia.[10]

Secondary evidence also confirms that pediatric dental rehabilitation under office-based general anesthesia is a major, growing trend. A 2011 survey of the ASDA membership revealed that 42% of its members spent most of their practice working with pediatric dentists, providing anesthesia to patients between the ages of 2 and 5 years (American Society of Dentist Anesthesiologists 2011 Membership survey, www.asda.org). The distribution of pediatric dentists and dentist

Table 3a. Comparison of NACOR-DENTAL and SCOR-ASDA surgical duration*

	Mean Duration of Surgery, min	*Standard Deviation*	*Standard Error*
NACOR-DENTAL	90.6	63.9	0.19
SCOR-ASDA	61.7	49.0	0.58

* NACOR-DENTAL indicates cases performed by physician anesthesiologists in hospitals and ambulatory surgery centers by physician anesthesiologists and their anesthesia care team, when applicable. SCOR-ASDA indicates cases performed by dentist anesthesiologists doing office-based anesthesia ($p < 0.01$).

Table 3b. Comparison of SCOR-ASDA Perioperative Times*

	Induction, min		*Surgical Time, min*		*Recovery, min*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Office-based	15.9	8.9	58.6	37.1	30.3	15.9
Freestanding ASC	14.2	12.3	74.9	72.1	33.9	13.9

* SCOR-ASDA indicates The Society for Ambulatory Anesthesia Clinical Outcomes Registry; ASDA indicates the American Society of Dentist Anesthesiologists. This table compares the duration of induction, surgical time and recovery time in office based anesthesia venues to freestanding ASCs. All cases were performed by dentist anesthesiologists.

anesthesiologists is also highly correlated. Approximately 20% of the nation's children age 5 years and younger live in 3 states: California, Texas, and New York.[11] The same 3 states share the highest proportion of pediatric dentists and dentist anesthesiologists. Although both specialties are unevenly distributed across the United States, the pairing of dentist anesthesiologists and pediatric dentists for office-based anesthesia has been shown to be an effective and desirable combination.[12] A 2012 survey of board-certified pediatric dentists reported that 20% to 40% used a dentist anesthesiologist for office-based anesthesia; however, 60% to 70% would use one if the service were available in their area.[13]

The age distribution of these databases also demonstrates the clear difference between the anesthesia practice of dentist anesthesiologists and oral and maxillofacial surgeons. Comparing the age distribution of these cases to data reported by Perrott et al,[4] it becomes clear that the average age range of the NACOR-DENTAL and SCOR-ASDA dental is much younger than that of cases from oral and maxillofacial surgery patients. The mean age of patients undergoing general anesthesia from dentist anesthesiologists was 8.9 years (SD 13.7), compared to 11.6 years (SD 15.5) with physician anesthesiologists verses 28.0 years (SD 16.1) with oral and maxillofacial surgeons (Figure 4). The specifics of anesthesia performed by oral surgeons differ from those provided by physician and dentist anesthe-

Table 4. ICD-9 Codes and CPT Codes in Registry Data

	NACOR-DENTAL	*SCOR-SAMBA*
ICD-9 codes	521.0 Dental caries, unspecified (69.5%) 520.6 Disturbance of tooth formation (9.0%) 522.4Acute apical periodontitis (2.6%) 522.5Periapical abscess (2.5%) 308.0 Predominant emotional disturbance (1.7%) 299.00 Autistic disorder (0.8%) 521.09 Other dental caries (0.7%) 523.10 Chronic gingivitis (0.5%) 521.2Caries extending into dentin (0.5%) 521.3Caries extending into pulp (0.4%)	
CPT codes	41899 Unlisted procedure dentoalveolar structures (99.1%) 41827 Excision of lesion, tumor (4.8%) 41806 Remove embedded foreign object (3.2%) 41826 Excision of lesion, tumor (2.8%) 41823 Excision of osseous tuberosities (2.1%)	00170 Anesthesia for intraoral procedures (98%) 00190 Anesthesia on facial bones (0.9%)

* CPT indicates Current Procedural Terminology; ICD-9, ninth edition of the International Diagnostic Coding system; NACOR, National Anesthesia Clinical Outcomes Registry; SAMBA, Society for Ambulatory Anesthesia; SCOR, SAMBA Clinical Outcomes Registry.

siologists in other significant ways beside average patient age. More than 99% of oral and maxillofacial surgeons provide their own anesthesia services while simultaneously providing office-based surgeries, using an operator-anesthetist model with dental assistants. Sixty-five percent of office-based deep sedations performed in oral surgery offices are for cases with a duration of 30 minutes or less (Figure 5). Less than 5% of oral surgeons use a separate anesthesia provider (dentist anesthesiologist, physician anesthesiologist, certified registered nurse anesthetists).[4] While the operator-anesthestist mode of anesthesia practice may be appropriate for the short procedures on nonpediatric (≤12 years old, healthy) patients that characterize oral surgery practice, it is not well suited for comprehensive dental rehabilitation, which tends to include significantly longer cases, cases that are more complex in nature, and younger children.

The overall duration of a dental rehabilitation case performed under office-based anesthesia is significantly shorter than dental rehabilitation performed under operating room anesthesia, as shown in Table 2. Surgical time is only a gross indicator of operational efficiency, since many factors can affect surgical time. It is interesting to note, however, that while there is no significant difference in the induction and recovery times, surgical time is significantly longer for cases performed in a freestanding ASC. Both figures contribute to the widely held belief that pediatric dentists are

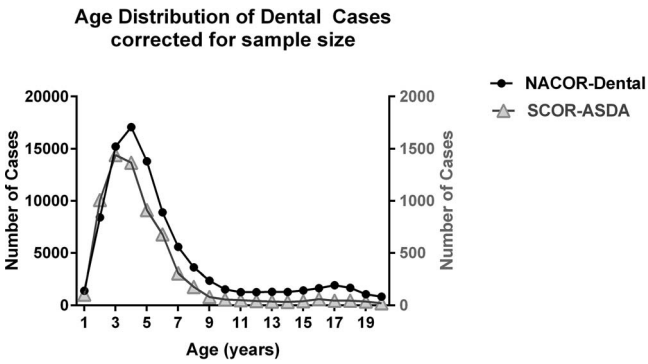

Figure 3. Age distributions for the National Anesthesia Clinical Outcomes Registry–DENTAL and Society for Ambulatory Anesthesia Clinical Outcomes Registry data sets (also shown in Figures 1a and 1b) and superimposes them on a graph where the *y*-axes are equalized. The near superimposition of the plots suggests a common source of patients for both registries. This source is most likely the population of children with early childhood caries.

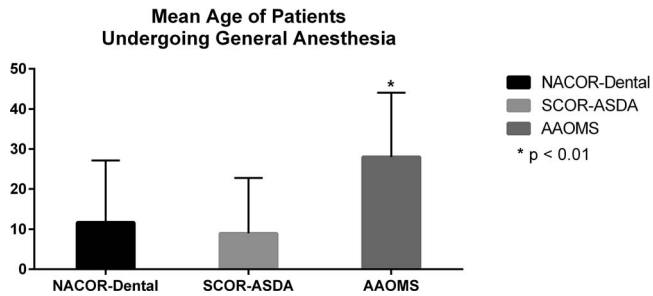

Figure 4. This graph compares the mean age of patients undergoing general anesthesia in this study to the mean age of patients undergoing general anesthesia in oral surgery offices, as reported by Perrott et al.[4] Although no significant difference in age is noted between the patients in the National Anesthesia Clinical Outcomes Registry (NACOR)–DENTAL and Society for Ambulatory Anesthesia Clinical Outcomes Registry (SAMBA-SCOR) data sets in this study, the difference in mean age for oral surgery patients is highly significant for both NACOR-DENTAL and SAMBA-SCOR.

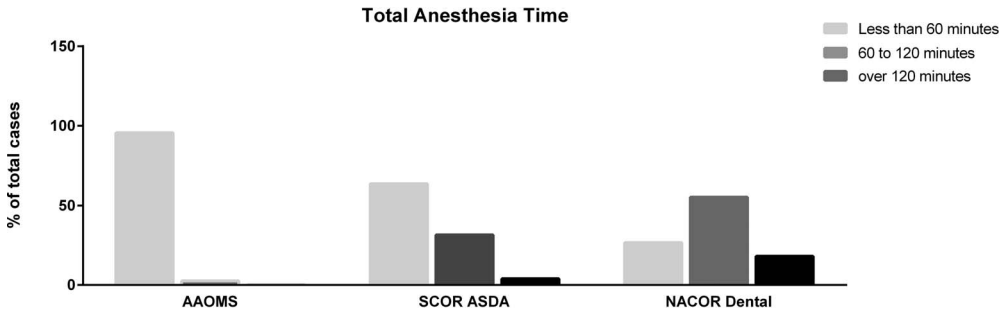

Figure 5. A comparison of total anesthesia time in the data sets of this study to total anesthesia time for patients undergoing general anesthesia in oral surgery offices, as reported by Perrott et al.[4] Nearly all cases of general anesthesia performed by oral surgeons are less than 30 minutes in length, whereas cases of 1–2 hours' duration or longer comprise a significant proportion of cases seen by the providers in the National Anesthesia Clinical Outcomes Registry–DENTAL and Society for Ambulatory Anesthesia Clinical Outcomes Registry data sets.

significantly more efficient when performing dentistry under anesthesia in their own offices as compared with hospital or ambulatory surgery centers. One might argue that patients treated in a hospital tend to have a higher ASA physical status classification rating, as shown in Table 1, and the cases are more likely to be complex. Although these statements may be true, these relatively small differences are unlikely to account for the nearly 50% difference in mean duration of surgery. Nor could the slower operating room times be attributed to care provided by resident anesthesiologists and surgeons, as academic medical centers accounted for only 6% of the cases logged into the NACOR registry.

The relative efficiency of office-based anesthesia versus hospital-based anesthesia has been described in other published reports.[14–16] Lalwani et al[17] compared dental rehabilitation under office-based general anesthesia to dental rehabilitation performed under hospital operating room–based general anesthesia using the same restorative dentist for all cases. In that study of 158 total cases, the mean office-based procedure time was 56.2 minutes compared with 130.9 minutes in the hospital operating room. In a separate study, Rashewsky et al[15] retrospectively examined 98 cases of pediatric dental rehabilitation, performed under general anesthesia in either a hospital operating room or office-based setting. The average total anesthesia time for the office-based setting was found to be 157 minutes compared with 222 minutes in the hospital operating room.[17,18] The familiar working environment for the dental surgeon and staff and the level of experience of the anesthesiologist are probably the most crucial factors for efficiency in an office-based dental surgical environment.[19] Both of these factors are optimized when a pediatric dentist uses a dentist anesthesiologist to perform general anesthesia on patients in the office environment.

Dental anesthesiology residencies are the only dedicated anesthesia training programs that require anesthesia training in office-based and non–operating room settings (minimum 100 cases). In the course of the 3-year dental anesthesia residency program, most dentist anesthesiologists receive approximately two-thirds of their anesthesia training within a hospital. These programs currently include a minimum of 800 cases of general anesthesia and deep sedation, of which a minimum of 125 must be performed on patients younger than 7 years. In addition, residents must complete a minimum of 75 general anesthetics on special needs patients, 50 nasal intubations, and 25 cases using advanced airway techniques. Once in practice, dentist anesthesiologists gather proficiency at an accelerated rate, since the scope of their practice is limited to patients with dental, oral, and maxillofacial diseases and disorders. The unique training and experience of this set of providers may also contribute to the efficiency of care delivered by dentist anesthesiologists that is suggested in these data.[20]

Given the very large incidence of ECC in United States children, it is puzzling why no medical or dental coding system includes a code for ECG. The ICD diagnostic coding system bears no mention of this condition. Similarly, no past or current Code on Dental Procedures and Terminology (CDT), a system developed and owned by the American Dental Association, mentions rehabilitation for ECC. Neither the current or past CDT coding systems are specific enough to adequately distinguish dental rehabilitation from other dental procedures. Improved insurance coding would enable both AQI and SCOR registries to provide more accurate and detailed outcomes data. As office-based anesthesia continues to grow, and best clinical practices and safety standards are more fully developed, insurance companies will be increasingly compelled to provide a reimbursement structure that reflects the realities of today's practice of anesthesia care delivery.

The cost of pediatric dental rehabilitation is very significant and rising. Nearly 20 years ago in Louisiana, in the period from 1996 through 1997, the estimated cost of a single admission for dental rehabilitation under general anesthesia was calculated at $1,508.[21] Current estimates are 3 to 4 times that amount. A recent review of 750 pediatric dental patients undergoing hospital-based general anesthesia was compared with office-based anesthesia for the same service. Results demonstrated a cost savings for anesthesia/facility fees of 84.4% if treatment was provided in the office environment as compared with in the hospital operating room.[22] Studies of office-based anesthesia over the past 25 years confirm a trend away from the hospital and into the outpatient and office-based environment, driven in large part by the lower cost and greater efficiency of office-based surgery. The findings of this study are consistent with this trend and also identify dentist anesthesiologists as being uniquely positioned to accommodate this shift in anesthesia practice.[23,24] Of course, hospital-based anesthesia will always be needed, particularly for patients with poor physical status, difficult airways, and lengthy, multidisciplinary surgeries. This may also explain the older average patient age of NACOR-DENTAL cases (Table 1) and the secondary bump in age distribution seen in NACOR-DENTAL cases (Figure 1a).

Several limitations of this study should be acknowledged. The data collected are based on standardized data collection forms that were not prepared specifically for this project. All clinical outcomes registries are limited by the nature of their data collection forms, which are designed to be used by a wide variety of practitioners, without being so lengthy and detailed that clinicians are unable to complete data in the course of clinical practice. Both databases are volunteer based, and neither of these data sets possessed controls for entering successive patients within a strictly defined period of time. Extrapolated conclusions from such registries are also limited by the degree to which the set of examined outcomes reflects the broader population of practitioners. However, both registries have filled a much needed void in tracking anesthesia outcomes and are the basis for several peer-reviewed papers. Collectively, these databases record data on approximately 25% of all anesthesia providers.[25] We anticipate that refinements to the NACOR and SCOR databases for dental anesthesia services should improve our knowledge and foster the creation of best clinical practices.

In conclusion, children 6 years and younger receive the greatest proportion of general anesthetics for dental/oral surgery rendered by both dental anesthesiologists and hospital-based anesthesia providers. These general anesthesia services are primarily provided for complete dental rehabilitation of ECC. Anesthesia for complete dental rehabilitation in the office-based setting by dentist anesthesiologists is significantly shorter than comparable care provided in the hospital operating room and surgery centers. The anesthesia care provided by dentist anesthesiologists is separate and distinct from anesthesia provided by oral and maxillofacial surgeons. Dentist anesthesiologists provide care to younger patients for procedures of longer duration using an independent anesthesia provider model versus oral and maxillofacial surgeons who use the operator-anesthesia model for shorter procedures on older patients. Despite the limited descriptive power of the current registries, valuable information on the provision of general anesthesia services for dentistry both inside and outside of the hospital has been obtained.

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REFERENCES

1. American Society of Dentist Anesthesiologists. Parameters of care. April 5, 2013. Available at: http://www.asdahq.org/sites/default/files/ASDA-POC-August-29-2013.pdf. Accessed February 6, 2016.

2. Commission on Dental Accreditation. Program options and descriptions. Available at: http://www.ada.org/en/coda/find-a-program/program-options-and-descriptions/. Accessed February 6, 2016.

3. Boynes SG, Moore PA, Tan PM Jr, Zovko J. Practice characteristics among dental anesthesia providers in the United States. *Anesth Prog*. 2010;57(2):52–58.

4. Perrott DH, Yuen JP, Andresen RV, Dodson TB. Office-based ambulatory anesthesia: outcomes of clinical practice of oral and maxillofacial surgeons. *J Oral Maxillofac Surg*. 2003;61:983–995.

5. Society for Ambulatory Anesthesia Clinical Outcomes Registry SCOR. Available at: http://www.sambahq.org/p/cm/ld/fid=80.

6. Anesthesia Quality Institute. National Anesthesia Clinical Outcomes Registry. Available at: https://www.aqihq.org/introduction-to-nacor.aspx. Accessed February 2, 2016.

7. Casamassimo PS, Thikkurissy S, Edelstein BL, Maiorini E. Beyond the dmft: the human and economic cost of early childhood caries. *J Am Dent Assoc*. 2009;140:650–657.

8. American Academy of Pediatric Dentistry. Policy on early childhood caries (ECC): unique challenges and treatment

options infant oral health care. *Pediatric Dentistry, Reference Manual*. 2014/2015;36(6):53–55.

9. Pediatric Oral Health Research & Policy Center. Technical report 2-2012: an essential health benefit: general anesthesia for treatment of early childhood caries. American Academy of Pediatric Dentistry. Available at: http://www.aapd.org/assets/1/7/POHRPCTechBrief2.pdf. Accessed February 6, 2016.

10. American Dental Association. 2012 survey of dental practice pediatric dentists in private practice: characteristics report. Available at: http://www.aapd.org/assets/1/7/SurveyofDentalPracticeReport.pdf. Accessed February 6, 2016.

11. United States Census Bureau. Quick facts. 2014. Available at: www.quickfacts.census.gov/qfd/states/36000.html. Accessed January 5, 2016.

12. Hicks CG, Jones JE, Saxen MA, et al. 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;59:3–11.

13. Olabi NF, Jones JE, Saxen MA, et al. The use of office-based sedation and general anesthesia by board certified pediatric dentists practicing in the United States. *Anesth Progr*. 2012;59:12–17.

14. Jani SR, Shaprio FE, Gabriel RA, Kordylewski H, Dutton RP, Urman RD. A comparison between office and other ambulatory practices: Analysis from the National Anesthesia Clinical Outcomes Registry. *J Healthc Risk Manag*. 2016;35(4):38–47. doi: 10.1002/jhrm.21223.

15. Shapiro FE, Punwani N, Rosenberg NM, Valedon A, Twersky R, Urman RD. Office-based anesthesia: Safety and Outcomes. *Anesth Analg*. 2014;119(2):276–85. doi: 10.1213/ANE.0000000000000313.

16. Shapiro FE, Jani SR, Liu X, Dutton RP, Urman RD. Initial results from the National Anesthesia Clinical Outcomes Registry and overview of office-based anesthesia. *Anesthesiol Clin*. 2014;32(2):431–44. doi: 10.1016/j.anclin.2014.02.018.

17. Lalwani K, Kitchin J, Lax P. Office-based dental rehabilitation in children with special healthcare needs using a pediatric sedation service model. *J Oral Maxillofac Surg*. 2007;65:427–433.

18. Rashewsky S, Parameswaran A, Sloane C, Ferguson F, Epstein R. Time and cost analysis: pediatric dental rehabilitation with general anesthesia in the office and hospital settings. *Anesth Prog*. 2012;59:147–153.

19. Carter J, Mohammad A. Building nonhospital-based platforms for ambulatory orthognathic surgery: facility, anesthesia and price considerations. *J Oral Maxillofac Surg*. 2009;67:2054–2063.

20. Cravero JP, Beach ML, Bilke GT, Gallagher SM, Hertzog JH, Pediatric Sedation Research Consortium. Incidence and nature of adverse events during pediatric sedation for procedures outside of the operating room: a report from the Pediatric Sedation Consortium. *Pediatrics*. 2006;118:1087–1096.

21. Griffith SO, Gooch BF, Beltran E, Sutherland JN, Barsley R. Dental services, costs and factors associated with hospitalization for Medicaid-eligible children in Louisiana 1996-1997. *J Public Health Dent*. 2000;60:21–27.

22. Jones JE. Emerging demands and cost effectiveness in pediatric dentistry for office-based general anesthesia sedation by dentist anesthesiologists in the United States. *Oral Health Dent Manag*. 2015;14(5):26. Available at: http://doi.org/10.4172/2247-2452.C1.014.

23. Shapiro FE. *Manual of Office-Based Anesthesia Procedures*. Philadelphia, PA: Lippincott, Williams & Wilkins; 2007.

24. American Hospital Association. The migration of care to non-hospital settings: have regulatory structures kept pace with changes in care delivery? July 2006. Available at: http://www.aha.org/research/reports/tw/twjuly2006migration.pdf. Accessed February 5, 2016.

25. Anesthesia Quality Institute. Media summary report. Available at: https://www.aqihq.org/publications.aspx. Accessed January 15, 2016.