Scientific Article

A survey of the American Academy of Pediatric Dentistry membership: nitrous oxide and sedation

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Abstract

Issues concerning the use of nitrous oxide (N_2O) and sedative agents by pediatric dentists in relation to recent changes in sedation guidelines of the American Academy of Pediatric Dentistry (AAPD) and the American Academy of Pediatrics (AAP) are relatively unexplored. A 48-item questionnaire addressing demographics, N_2O equipment, N_2O use, safety, and personnel was mailed to 2,650 active AAPD members in the United States and Canada. The 1,758 (66.3%) responses were reviewed and descriptive statistics were obtained using SPSS/PC+ statistics package. Results suggest the respondents were representative of the demographics of the AAPD membership. The majority of respondents (89%) used N_2O, with a central delivery system being most popular. The majority (74%) did not use any monitors when using N_2O alone; 10% did not use monitors when N_2O was used in combination with other sedative agents. A majority (59%) did not use a time-based recording of physiological parameters. In conclusion, a mixed impression was found about practitioners' use of N_2O and sedative agents, suggesting wide variability in practitioner habits related to pharmacologic patient management. (Pediatr Dent 18:287–93, 1996)

Sedation guidelines of the American Academy of Pediatric Dentistry (AAPD) and the American Academy of Pediatrics (AAP) were first published in 1985.[1] Considerable effort was expended to develop guidelines that were acceptable to both organizations. However, because of new research in clinical sedation and development of monitoring since the publication of the 1985 guidelines, it became apparent that change was needed. The AAP revised and published new guidelines in 1992[2] and the AAPD in 1993[3]; however, notable differences were evident between the two guidelines in the use of nitrous oxide (N_2O) and oxygen analyzers.

One of the most striking differences between the two sets of current guidelines is the issue of N_2O — specifically monitoring requirements. AAP's guidelines imply that N_2O in a concentration of 50% or less should not be used with any other sedative agent unless the patient is monitored in accordance with deep sedation protocol. Also, oxygen analyzers are required for all conditions. In comparison, AAPD guidelines do not stipulate levels of monitoring as a function of agents used with N_2O, with the exception that only clinical monitoring is required when N_2O is used in combination with "minor tranquilizers" (e.g., hydroxyzine or diazepam). Further, the use of oxygen analyzers is required only under specific conditions (viz., whenever N_2O equipment is capable of delivering greater than 80% N_2O); otherwise, analyzers are only recommended.

A previous study[4] involved a survey of AAPD membership regarding the use of sedative agents including N_2O. The study was associated with the influence of 1985 AAPD Conscious Sedation Guidelines on sedation practices and hence, preceded the recently revised AAP and AAPD guidelines. Information reported regarding N_2O was limited solely to its frequency of use.

Implications of the differences between revised AAP and AAPD guidelines and a general lack of information concerning specific uses of N_2O and sedative agents by private practitioners prompted the AAPD Education Foundation to fund a survey on N_2O and sedation that was completed in the autumn of 1993.

The purpose of this study was to determine: 1) the relative extent of N_2O use by pediatric dental practitioners; 2) issues associated with N_2O equipment (e.g., methods used to reduce ambient air contamination); and 3) related safety concerns (e.g., monitoring and personnel issues). Secondarily, information on other sedative agents was obtained as a reference for comparison to N_2O when used alone.

Methods

The survey and instructions were developed by the AAPD Research Committee. The survey was mailed to all active and fellow AAPD members in the United States and Canada in the summer of 1993. It included 48 questions addressing five areas, including demographics, N_2O equipment, N_2O use, safety, and personnel concerns. Each question had multiple responses

and, for some items, members were requested to mark as many of the response categories as applied to their practice circumstances.

A total of 2,650 surveys was mailed and 1,758 (66.3%) were returned. The responses revealed that the number of respondents varied for each question (respondents were selective in determining which questions they answered). Descriptive analyses were completed using SPSS/PC+ (Chicago, IL) statistics package. Percentages reported for any given question reflect only those who responded to that question rather than the total questionnaires returned.

TABLE 1. DEMOGRAPHICS OF RESPONDENTS

Demographic	*Number of Responses*	*Percent*
Years Practiced		
0–10	325	16.1
11–15	324	21.9
16–20	217	19.5
> 20	355	28.1
(Missing 62)		
Type of Practice		
Solo	937	55.2
Partnership	386	22.7
Hospital	38	2.2
Academics	82	4.8
Other	154	9.1
Combination	88	6.0
(Missing 61)		
Patients/week		
1–25	113	6.7
26–50	202	11.9
51–100	534	31.5
> 100	838	49.4
None	6	0.4
(Missing 65)		
Boarded		
No	1136	67.2
Yes	556	32.8
(Missing 66)		
Area of Practice		
Northeast	439	26.4
Southeast	325	19.6
North central	324	19.5
South central	217	13.1
West	355	21.4
(Missing 98)		
Location of Practice		
Rural	139	8.2
Suburban	1158	68.3
Inner urban	285	16.8
Other	114	6.7
(Missing 62)		

Results

Demographic information

Seven survey questions examined practitioner demographics. In essence, the analysis indicated that the responses were representative of the demographics of the AAPD membership. Table 1 shows a summary related to practitioner demographics. There was an even distribution in the categories for number of years respondents practiced. The majority were solo practitioners seeing more than 100 patients per week and had a practice located in a suburban area. Approximately one-third were Diplomates of the American Board of

TABLE 2. INFORMATION ON NITROUS OXIDE EQUIPMENT

Issue Addressed	*Number Responding*	*Percent*
Type of N_2O System		
Portable	226	13.2
Central	1203	69.8
Both	104	6.0
None	190	11.0
(Missing 35)		
Brand of N_2O System		
Porter Brown	488	33.7
McKesson	264	18.2
Accutron	129	8.9
Quantiflex	136	9.4
Other	191	13.2
Combinations	240	16.6
(Missing 310)		
Methods of Removing Gas		
Scavenging	780	49.5
Fans/exhausts	22	1.4
Increased air turnover	9	0.6
Larger operatories	18	1.1
Combinations	677	43.0
None	69	4.4
(Missing 183)		
Methods to Monitor Ambient Gases		
Chemical badges	220	14.2
Infrared	51	3.3
Don't know	84	5.4
Combinations	30	2.0
None	1165	75.1
(Missing 208)		
Repairs to N_2O Systems		
No	1445	92.5
Yes	118	7.5
(Missing 195)		
Equipment Problems Imperiling Patients		
No	1525	97.4
Yes	41	2.6
(Missing 192)		

Pediatric Dentistry and differences were not noted in the distribution of respondents among the five major regions of the U.S.

Nitrous oxide equipment

Six questions examined factors related to N_2O equipment. Table 2 shows a summary of responses related to some of these questions. The majority of respondents had central delivery systems and the most popular was Porter Brown™ (Hatfield, PA), followed by McKesson™ (MDT Co, Charleston, SC), Quantiflex™, Accutron™ (Phoenix, AZ), and others. Several respondents had a combination of systems.

Scavenging systems, either as the sole method or as used in combination with other methods, were the most popular means of removing wasted or exhaled gases. Chemical-sensitive badges were the most popular means to monitor ambient gases, followed by infrared testing, or a combination of monitoring systems. The majority of respondents did not employ an ambient N_2O monitoring system, but for those who did, the level of concentration usually was less than 50 ppm (Table 3).

One hundred and eighteen respondents (7.5%) acknowledged having their N_2O deliver system altered, repaired, or modified. A random sampling of these 118 respondents indicated their systems had been upgraded or changed because of new equipment installation, rubber hose/mask/bag deterioration, failure of fail-safe systems, malfunction of flow meters, and malfunctioning or crossed lines. In an unrelated question, 41 (2.6%) mentioned that their equipment problems conceivably could have imperiled the safety of patients. Examples of important problems identified from this question included crossed lines (N = 8), failure of fail-safe features (N = 4), cross-tanks, mislabeled tanks, and altered pin-indexing (N = 10).

TABLE 3. AMBIENT LEVELS OF NITROUS OXIDE IN OFFICES

Concentrations	*Frequency*	*Percent*
< 50 ppm	336	24.5
> 50 ppm	96	7.0
Never tested	942	68.5
(Missing 384)		

Nitrous oxide utilization

Table 4 is a summary of respondents' reported uses of N_2O and sedatives. The majority of respondents titrated N_2O throughout operative procedures while others titrated initially, then used a set concentration. A few never titrated, using only set concentrations. The range of N_2O concentration varied, but only a small number exceeded 50%.

A goal of the survey was to collect data on the combined use of N_2O and sedative agents for the sake of comparison to N_2O alone. Responses indicated that in practitioners' patient pools, the number varied for those requiring N_2O alone compared to its combination with other sedatives. In general, most respondents were consistent in indicating that 20% or less of their patient pool required either N_2O alone or a combination of N_2O with sedatives; however, the use of N_2O alone compared to its combination with sedatives was proportionately more necessary for the remaining pool of patients. Also, N_2O alone was used at a proportionately higher rate during the week time period than was

TABLE 4. USES OF NITROUS OXIDE AND SEDATIVES

Parameter	*Number of Responses*	*Percent*
Use of Titration		
Initially only	411	27.6
Throughout	886	59.5
Never	192	12.9
(Missing 269)		
Ranges of N_2O Used		
1–10%	5	0.3
11–30%	201	13.2
31–50%	566	37.2
>50%	28	1.8
Combinations (10–50%)	720	47.5
(Missing 238)		
Frequency of Use of N_2O Alone		
None	228	14.7
1–2/Week	332	21.4
3–5/Week	169	10.9
> 5/Week	821	53.0
(Missing 208)		
Patient Pool Requiring N_2O		
1–20%	767	49.4
21–40%	261	16.8
41–60%	176	11.3
61–80%	127	8.2
81–100%	94	6.1
None	127	8.2
(Missing 106)		
Frequency of Use of N_2O and Sedatives		
None	614	39.2
1–2/Week	433	27.6
3–5/Week	219	14.0
> 5/Week	300	19.2
(Missing 192)		
Patient Pool Requiring N_2O and Sedatives		
1–20%	794	51.4
21–40%	101	6.5
41–60%	35	2.2
61–80%	24	1.6
81–100%	109	7.1
None	482	31.2
(Missing 213)		

N_2O in combination with sedatives. There was not much difference in respondents' estimation of success with N_2O alone compared to N_2O in combination with sedatives, although a slight majority perceived success greater than 76% for both types of appointments (Table 5).

TABLE 5. PRACTITIONER ESTIMATION OF SUCCESS WITH NITROUS OXIDE ALONE OR IN COMBINATION WITH SEDATIVES

Estimated Success	*Number of Responses*	*Percent*
Success with N_2O Alone		
< 25%	146	9.8
26-50%	134	9.0
51-75%	372	24.9
> 76%	839	56.3
(Missing 267)		
Success with N_2O and Sedatives		
< 25%	154	13.5
26–50%	132	11.5
51–75%	288	25.2
> 76%	569	49.8
(Missing 615)		

TABLE 6. FREQUENCY OF EYE CLOSURE

Relative Frequency	*Number of Responses*	*Percent*
Eyes Closed With N_2O and Sedatives		
Never	158	14.4
Infrequently	517	46.9
Frequently	396	35.9
Always	31	2.8
(Missing 656)		
Eyes Closed With N_2O Alone		
Never	527	35.2
Infrequently	858	57.7
Frequently	104	7.0
Always	1	0.1
(Missing 271)		

Safety of nitrous oxide and sedative agents

A larger proportion of respondents indicated that children closed their eyes less frequently for periods exceeding 5 min when N_2O was used alone than when combined with sedatives (Table 6). Interestingly, the majority indicated that children never or infrequently closed their eyes during a visit involving N_2O and sedatives.

Table 7 shows a summary of information gathered on monitoring. The majority of practitioners indicated they had a combination of monitors in their offices with the most frequent combination being the pulse oximeter, blood pressure cuff, and stethoscope. However, the overwhelming majority indicated they did not use any monitors when N_2O was used alone. When N_2O was used in combination with other sedative agents, the pulse oximeter was the single most frequently used monitor and the most frequent combination of monitors was pulse oximeter, blood pressure cuff, and stethoscope. Also, the majority of respondents always used a minimum of a pulse oximeter when N_2O was used in combination with other sedatives. A small minority reportedly did not use any monitors when N_2O was combined with other sedative agents.

A larger percentage of practitioners indicated that they had experienced a compromised airway as a result of a patient being "deeply sedated" with N_2O combined with sedatives than with N_2O alone (Table 8). However, most reportedly never experienced a compromised airway with N_2O alone. When asked if a time-based recording of physiological parameters was maintained, a slight majority indicated they did not (Table 9).

A small minority had to use the emergency medical system (EMS) or a code for an emergency resulting from a sedation (Table 9). Reasons given for the emergencies generally were not related to depth of sedation during the procedure, but included — among others — anaphylaxis, malignant hyperthermia, aspiration, and preoperative

TABLE 7. INFORMATION ON MONITORING

Parameter	*Pulse Oximeter*	*Blood Pressure Cuff*	*Stethoscope*	*Other*	*Combinations*	*None*
Monitors in office (Missing 166)	92 (5.8%)	16 (1%)	66 (4.2%)	7 (0.4%)	1292 (81.3%)	116 (7.3%)
Monitors used with N_2O alone (Missing 256)	104 (6.9%)	11 (0.7%)	26 (1.7%)	123 (8.2%)	126 (8.5)	1112 (74%)
Monitors used with N_2O + sedatives (Missing 635)	270 (24%)	6 (0.5%)	39 (3.5%)	24 (2.1%)	511 (54.6%)	171 (15.2%)

	Never	*Infrequently*	*Frequently*	*Always*
Pulse oximeter used with N_2O and sedatives (Missing 604)	294 (25.5%)	84 (7.3%)	156 (13.5%)	620 (53.7%)

over-sedation due to patient self-medication.

The majority of respondents were certified in basic life support and a small minority were certified in either pediatric advanced life support or advanced cardiac life support (Table 10). The most popular frequency of having emergency drills involving staff in the office was once a year, however many reported never having had a drill (Table 11).

A minority of respondents reported that personnel in the office inquired or complained about ambient effects of N_2O. The most frequent personnel concerns were related to effects on reproduction, pregnancy, and miscarriage (Table 12).

TABLE 8. EXPERIENCE WITH COMPROMISED AIRWAYS

Circumstance	*Number of Responses*	*Percent*
N_2O Alone		
No	1483	97.8
Yes	33	2.2
(Missing 242)		
N_2O and Sedatives		
No	857	70.0
Yes	368	30.0
(Missing 533)		

TABLE 9. DISTRIBUTION OF RESPONSES REGARDING TIME-BASED RECORDING AND NEED FOR EMERGENCY MEDICAL SERVICE

Parameter	*No*	*Yes*	
Use of time-based record of physiological parameters	879 (58.7%)	619 (41.3%)	(Missing 260)
Need for emergency medical service resulting from a sedation	1492 (94.9%)	81 (5.1%)	(Missing 185)

Discussion

The demographic information provides evidence that the sample is representative of AAPD membership because it reveals similar demographic characteristics to other AAPD membership surveys.[5-8] Further, the relatively large response rate and consistency of demographics with previous studies strongly suggest that the study is a valid reflection of the use of N_2O in the private practice setting among AAPD members.

One purpose of the study was to determine the number of pediatric dentists who have and use N_2O in their offices. The findings indicated that the overwhelming majority of practitioners have N_2O in their offices with most using a central method of delivery. Porter Brown™ units are relatively popular. The reason for the popularity is unknown, but may be related to its scavenging system incorporated into a softer, more pliable, and well-fitting mask. Further, N_2O is employed more than five times per week by a majority of practitioners compared to considerably fewer who use N_2O in combination with other sedative agents as frequently (821 versus 300 respondents, respectively). Similar findings have been reported by others.[4,6,7]

Results of this survey suggest that N_2O is a pervasive, popular pharmacologic agent used either alone or in combination with other sedatives. Consequently, the effects of sedation guidelines that limit the use of N_2O in combination with other sedatives could have a dramatic impact on the way private practitioners care for children. Even though the results indicated a few emergencies have occurred, one must consider their relatively limited occurrence over decades of sedative trials. Further, it remains unclear whether or not N_2O in combination with other sedatives was a prominent, contributing factor to these emergencies.

TABLE 10. LEVELS OF CERTIFICATION IN OFFICE

Level	*Frequency*	*Percent*
Basic life support (BLS)	1211	73.7
Pediatric advanced life support (PALS)	17	1.0
Advanced cardiac life support (ACLS)	28	1.7
Combination	381	23.2
None	6	0.4
(Missing 115)		

TABLE 11. FREQUENCY OF EMERGENCY DRILLS IN OFFICE

Frequency	*Count*	*Percent*
Monthly	41	2.5
Quarterly	193	11.8
Twice/year	327	19.9
Once/year	741	45.1
Never	340	20.7
(Missing 118)		

TABLE 12. PERSONNEL CONCERNS ABOUT NITROUS OXIDE

	Number of Responses	*Percent*
Parameter		
Ambient effect		
No	1186	76.2
Yes	371	23.8
(Missing 201)		
Type of Concern Expressed		
Reproduction	279	71.2
Neurologic	6	1.5
Other	28	7.1
Combinations	79	20.2
(Missing 1366)		

Most practitioners do not monitor ambient N_2O in their offices. Likewise, almost 70% indicated they had *never* tested the ambient levels of N_2O in their offices. However, only 4% did not use any method of removing wasted or exhaled gases, and less than a quarter of respondents indicated their personnel inquired of the ambient effects of N_2O. Personnel usually were concerned with the effects on the reproductive system.

Unfortunately, these findings hint that few practitioners have their machines checked on a yearly basis as recommended by the guidelines. Also, they may not heed OSHA recommendations,[9] which have been questioned recently.[10] But many appear cognizant of the need to practice some type of environmental hygiene as evidenced by the majority using some type of method to eliminate gases. Failure to comply uniformly to guidelines in a private practice setting may not be surprising because of its implied or perceived "outside", minimally enforced regulation of a privately owned operation. Lack of compliance to aspects of similar guidelines is not uncommon in the medical community.[11] However, strong efforts to comply with the guidelines, for the sake and safety of children and office staff, should be a top priority of practitioners.

It is interesting that several practitioners reported problems with crossed lines during installation of N_2O equipment. The current AAPD guidelines require that any installation of new equipment be checked with an oxygen analyzer recommended for such purposes. Proponents believe that oxygen analyzers should be standard on all N_2O units as they are on anesthesia machines; however, N_2O units in dental operatories do not use a closed system. Patients can breathe room air as needed through their mouths during inhalation of N_2O via a nasal mask. The cost — economically, logistically, and politically — of requiring the implementation of oxygen analyzers on all existing N_2O dental units would be prohibitive.

Whether used alone or in combination with other agents, N_2O was viewed as beneficial to patients needing pharmacologic management. For instance, of those responding, at least half believed that N_2O either alone or in combination with sedatives was beneficial in more than 76% of patients receiving it. Furthermore, the majority of respondents believed that at least some proportion of their patient pool required either N_2O or a combination of N_2O with sedatives for patient management. In short, most practitioners have confidence in N_2O as a valuable adjunct in managing a particular subset of their patient population.

The results suggested that some adverse events were due to parents not following directions and overdosing children. It was not possible to determine from the survey if these events occurred before or after the issuance of sedation guidelines. The 1985 guidelines were vague regarding prescriptions. The 1993 guidelines state that prescriptions other than for "minor tranquilizers" must be administered by the practitioner and documented in the patient's chart. Minor tranquilizers may be prescribed by a practitioner and administered by a responsible adult. It was the intent of the committee that developed the 1993 guidelines that minor tranquilizers include hydroxyzine and diazepam only, not chloral hydrate, narcotics, major tranquilizers (e.g., promethazine), dissociative agents, or general anesthetics.

Most practitioners do not use any monitors when N_2O is used alone which, no doubt, reflects practitioners' confidence and experience in the safety of N_2O. However, the majority does use at least one monitor when N_2O is used in combination with other sedatives. The pulse oximeter, either with or without a blood pressure cuff and stethoscope, is most popular. One puzzling finding is that 15.2% (N = 171) of respondents do not use monitors when using N_2O in combination with other sedative agents. Furthermore, 25.5% (N = 294) reportedly never use a pulse oximeter when N_2O is used with other sedative agents; however, they do use other monitors. One interpretation is that when minor tranquilizers (hydroxyzine) or anxiolytic agents (diazepam) are used with N_2O, such a combination is perceived as an extremely mild state of sedation wherein the patient is expected to always be awake and responsive. In this scenario, only clinical monitoring is needed according to the AAPD guidelines. Another alternative is that a small number of practitioners, who do not monitor for any number of reasons, elect to ignore the guidelines and safety afforded by physiological monitors. If the latter interpretation is correct, this is an area of concern that should be addressed through research, educational programs, or more stringent intra-professional regulation for the safety of children.

The distribution of responses to questions relative to compromised airways thought to be due to "deep" sedation under conditions of either N_2O alone or in combination with other agents was interesting. Many (N = 533) did not respond to the question involving the combination of agents. Of those responding, 30% (N = 368) noted compromised airways when combinations of agents were used. Seventy percent (N = 357) indicated that they had never noted compromised airways. Only 2% (N = 33) noted compromised airways when using N_2O alone.

These findings must be interpreted cautiously because the term "compromised airways" was not defined in the survey instrument. Thus, coughing or gagging, even under conditions of N_2O only, may have been interpreted by some respondents as a compromised airway, when such a response more likely suggests a noncompromised, functional airway in most circumstances. On the other hand, one cannot determine the degree and timing of airway vigilance and competency in its management on the part of the practitioner in a clinical setting from this survey. The distribution of responses for these questions may again reflect the semantics of the term "compromised". It

seems reasonable to expect that any practitioner experienced in conscious sedation with multiple agents has encountered some children who required a head tilt/chin lift procedure to open the airway. One study[12] showed that 50% N_2O alone decreased the number of swallows and increased swallowing latency when the oropharynx in humans is challenged with different volumes of water. However, it is not known if such a depressive effect is clinically and adversely significant.

A similar distribution of responses was seen for closing the eyes either when N_2O is used alone or in combination with other agents. That is, fewer individuals responded to the question when a combination of agents was used. More noted the eyes never closed when N_2O was used alone (35%) compared to when it is used in combination with other agents (14%). But the majority of respondents noted that the eyes do close under any of these conditions, either on an infrequent or frequent basis. N_2O can be beneficial in inducing some degree of relaxation in patients; however, it is likely the level of anxiety is mild to moderate in most patients minimally requiring N_2O inhalation. The significance of eye closure during sedation is not fully appreciated and may be the result of several mechanisms, including among others, 1) direct pharmacologic induction of sleep or unconsciousness or 2) indirect pharmacologic reduction in anxiety with restful eye closure. Since responsiveness to verbal stimulation may be dampened under either condition, adjunctive monitoring of the airway is a reasonable though not necessarily required procedure.

The personnel in the majority of offices had certification in Basic Life Support. A minority of the respondents never practiced emergency drills in the office, but most did at least once a year. It is not possible to determine if this is a common finding among health care professionals; however, one study indicated that the proportion of pediatricians confident in managing the initial stabilization of emergencies in the office ranged from 25 to 58%.[13] Since a minority of respondents have experienced the need for EMS or a code surrounding circumstances of a sedative visit, and an association between length in practice to a higher likelihood of an emergency may be expected, emergency drills seem warranted.

A slight majority of respondents indicated they did not use a time-based recording of physiological parameters during sedations. Both the 1985 and 1993 guidelines recommend that certain parameters be measured and recorded on an intermittent basis, and such a response suggests a generalized disregard for portions of the guidelines. Again, the reason for this finding is unknown but may be related to several factors, including among others, busyness, lack of an established habit of monitoring, or a perception that it is not needed. In a private practice setting, the only time such a record becomes legally necessary is if a significant adverse event occurs. Under such conditions, the lack of such a record could be devastating.

In summary, the results of the study suggest a mixed impression about various practitioners' use and management of N_2O and sedative agents. There were a few alarming but confusing findings (e.g., the relatively large number of practitioners who fail to monitor ambient levels of N_2O and do not monitor during sedations). Also, some findings were previously unpublished (i.e., that Porter Brown is the most popular machine). There was enough substantive data to suggest two directions of future efforts by the leadership of our profession: 1) the need for more intensely focused and controlled research and 2) the need to provide practitioners with contemporary scientific information related to the use of N_2O and sedative agents.

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