Policy on Minimizing Occupational Health Hazards Associated with Nitrous Oxide

Latest Revision

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Purpose

The American Academy of Pediatric Dentistry (**AAPD**) recognizes that exposure to ambient nitrous oxide (N_2O) may be an occupational health hazard for dental personnel and encourages practitioners to take all precautions to minimize associated risks.

Methods

This policy was developed by the Clinical Affairs Committee, adopted in 1987[1], and last revised by the Council on Clinical Affairs in 2018[2]. This update used electronic database and hand searches of articles in the medical and dental literature using the following parameters: terms: nitrous oxide, occupational exposure, AND dentistry; fields: all; limits: within the last 10 years, English. Additionally, recommendations from the National Institute for Occupational Safety and Health (**NIOSH**) were reviewed.[3,4] Expert opinions and best current practices were relied upon when sufficient scientific data were not available.

Background

Nitrous oxide is an inhalation agent commonly used in dentistry for analgesia/anxiolysis. When used in accordance with recommended techniques and patient selection criteria, N_2O/oxygen inhalation exhibits a high degree of efficacy and patient safety in the clinical setting.[5-9] Occupational exposure to ambient N_2O has been studied for decades, yet the effects of ambient N_2O exposure on dental personnel remain uncertain. Early reports, many of which came from animal studies[10] and/or preceded scavenging devices[11] and ventilation systems, implicated chronic occupational exposure of unscavenged N_2O in reproductive effects[10,12,13] (e.g., decreased sperm count, spontaneous abortions[14], birth defects[10,15]), liver[14] and kidney damage[10,12,15], and neurologic considerations[10,15] (e.g., memory, hearing). In offices using scavenging systems, female dental staff frequently (i.e., three or more days a week) exposed to N_2O were found to have no elevated risk of spontaneous abortion.[16,17] A paucity of clinical research establishing a causal relationship between chronic exposure of dental personnel to N_2O and health problems continues. A recent systematic review on workplace exposure to volatile anesthetics including N_2O reported evidence is both scarce and inconsistent regarding adverse effects.[18] The dentist's exposure often is noted to be greater than that of the dental assistant.[19-21] Exposure may increase due to patient factors, with a three-fold increase in ambient N_2O levels noted when patients talked, cried, or held their breath during administration of local anesthesia.[22] Furthermore, as the concentration of administered N_2O increases, so does the ambient N_2O level in the operator's breathing zone.[22]

NIOSH reported in 1977 that primary concerns of chronic N_2O exposure were diminished cognition, performance, audiovisual ability, and dexterity; conclusions on reproductive health were not definitive.[10] That report included a recommended exposure limit (**REL**) to a time-weighted average (**TWA**) of 25 parts per million (**ppm**) yet noted 25 ppm might not be achievable and was subject to review and revision.[23] Shortly thereafter, NIOSH published a technical report intended to help limit occupational exposure in the dental setting to 50 ppm[24] although the REL remained unchanged[25]. In 1986, the American Conference of Governmental Industrial Hygienists established the threshold limit value (**TLV**) for N_2O exposure at 50 ppm.[25] Unless a state or the federal government adopts a TLV, this level is merely a recommendation.[26] Only the Occupational Health and Safety Administration (**OSHA**) can establish a legal limit for exposure (permissible exposure limit [**PEL**]).[26] Notably, OSHA has not established a PEL for N_2O exposure in the healthcare setting.[25] The International Labor Organization and World Health Organization also have established a TLV of 50 ppm as TWA and noted that N_2O is not carcinogenic.[27]

The introduction of methods to scavenge N_2O and other control measures has been effective in reducing ambient N_2O in the dental environment.[21,28] System maintenance, scavenging of expired gases, ventilation of the operatory/room air exchange, use of the minimal effective dose, and patient selection[9] and management are important to maintaining the lowest practical levels in the dental environment.[3,4,29] Leaks at system connectors and degradation, cracks, and tears in system components may allow N_2O to enter room air, increasing

ABBREVIATIONS

AAPD: American Academy of Pediatric Dentistry. **N_2O:** Nitrous oxide. **NIOSH:** National Institute for Occupational Safety and Health. **PEL:** Permissible exposure limit. **ppm:** Parts per million. **REL:** Recommended exposure limit. **TLV:** Threshold limit value. **TWA:** Time-weighted average.

occupational exposure. Frequent and continual inspection will allow timely maintenance and replacement of components thereby minimizing environmental exposure.[30] A double-chamber mask delivery system has been shown to be more effective in the removal of waste N_2O than a single-chamber mask with a scavenging cap.[31,32] Use of a well-fitted double-chamber mask with recommended scavenging system flow rate can decrease occupational exposure to N_2O.[31,33] Recently, disposable masks and mask/circuits have been developed and marketed for improved infection control, but studies comparing their efficacy in scavenging waste gases are lacking.

Establishing a balance of gas flows entering and exiting the delivery system is important for effectiveness and decreasing ambient levels. If the flow of inhalation gases overinflates the breathing bag, excessive leakage from the mask can occur.[4] Allowing the bag to expand and collapse with each breath ensures proper delivery of gases. Likewise, the rate of suction of the exhaled gases needs to be sufficient to allow removal of gases from the system but maintain the desired clinical effects. NIOSH has recommended that the exhaust ventilation of N_2O from the patient's mask be maintained at an air flow rate of 45 liters per minute and vented outside the building away from fresh air intakes.[4] However, scavenging at this rate has been shown to reduce the level of psychosedation achieved with N_2O inhalation.[34]

Additional steps can be taken to lower the ambient N_2O levels. Ambient concentration will change with increased room air turnover and percentage of fresh air intake. One hundred percent clean outdoor air has been recommended for dental operatory ventilation.[3] Well-separated supply and exhaust vents allow good mixing and prevent short-circuiting.[3] Use of supplemental measures, such as high-volume dental suction placed in proximity to the mouth[22,35] and administration of 100 percent oxygen following termination of N_2O flow[36], has been shown to reduce ambient N_2O levels significantly. Measuring levels of N_2O in the dental operatory can be helpful in determining the type and extent of remediation necessary to decrease occupational exposure.

Patient selection is an important consideration in reducing ambient N_2O levels.[9,29] Patients who are unwilling or unable to tolerate the nasal hood and those with medical conditions (e.g., obstructive respiratory diseases, emotional disturbances, drug dependencies) that contraindicate the use of N_2O are candidates for other behavior guidance techniques.[9,29] In the dental environment, patient behaviors such as talking, crying, and moving have been shown to result in significant increases in baseline ambient N_2O levels despite the use of the mask-type scavenging systems.[22,37] Titration of N_2O concentration levels in relation to procedure difficulty can help lower levels of ambient N_2O. N_2O can be discontinued once adequate anesthesia is achieved[38], or decreased levels can be maintained during easier procedures and increased for stimulating procedures[39].

Policy statement

The AAPD encourages dentists and dental auxiliaries to maintain the lowest practical levels of N_2O in the dental environment. The AAPD also encourages practitioners to weigh the risks and benefits of using N_2O when treating pediatric patients. Adherence to the following safety practices can help minimize occupational exposure to N_2O.

- Educate dental personnel on minimizing occupational exposure to and potential abuse of nitrous oxide.
- Use scavenging systems that remove N_2O during patient's exhalation.
- Ensure that exhaust systems adequately vent scavenged air and gases to the outside of the building and away from fresh air intake vents.
- Use, where possible, clean outdoor air for dental operatory ventilation.
- Monitor ambient N_2O levels in dental operatories in accordance with local and state regulations.
- Implement a plan for careful, regular inspection and maintenance of the nitrous oxide/oxygen delivery equipment according to manufacturer's recommendations.
- Carefully consider patient selection criteria (e.g., tolerance of nasal hood, ability to breathe from the nose, cooperative potential, recent illnesses, indications, contraindications) prior to administering N_2O.
- Select a properly-fitted double-chambered mask size for each patient.
- During administration, visually monitor the patient and titrate the flow/percentage to the minimal effective dose of N_2O.
- Encourage patients to minimize talking, moving, and mouth breathing during N_2O administration.
- Use high volume dental suction when possible during N_2O administration.
- Use a rubber dam or isolation devices with suction evacuator when possible during operative treatment.
- Administer 100 percent oxygen to the patient for at least five minutes after terminating N_2O flow to replace the N_2O in the gas delivery system.

The AAPD encourages an interprofessional approach between dental team members who are pregnant or trying to conceive and their physicians regarding the effects of N_2O on reproductive health to assure comfort and safety with the administration of nitrous oxide/oxygen analgesia/anxiolysis.

The AAPD encourages research on the efficacy of newer-style (e.g., disposable mask, disposable mask/circuit) nasal hoods in scavenging waste gases. Furthermore, because of the paucity of literature on health effects of occupational N_2O exposure in the dental setting with modern delivery, scavenging, ventilation, and monitoring systems, the AAPD encourages additional studies and periodic review of the occupational exposure recommendations by NIOSH.

References

1. American Academy of Pediatric Dentistry. Minimizing health hazards associated with the use of nitrous oxide/oxygen analgesia. 1987. Reference Manual 1991-1992. Chicago, Ill.: American Academy of Pediatric Dentistry; 1991:30.
2. American Academy of Pediatric Dentistry. Policy on minimizing occupational health hazards associated with nitrous oxide. Pediatr Dent 2018;40(6):104-5.
3. National Institute of Occupational Safety and Health. Control of Nitrous Oxide in Dental Operatories. DHHS (NIOSH) Publication Number 96-107. 1996. Available at: "https://www.cdc.gov/niosh/docs/hazardcontrol/hc3.html". Page last reviewed: June 6, 2014. Accessed January 26, 2023.
4. National Institute of Occupational Safety and Health. Controlling Exposures of Nitrous Oxide During Anesthetic Administration. Cincinnati, Ohio: National Institute of Occupational Safety and Health; 1994. DHHS/NIOSH Publication No. 94-100. Page last reviewed: June 6, 2014. Available at: "https://www.cdc.gov/niosh/docs/94-100/". Accessed February 9, 2023.
5. Buhre W, Disma N, Hendrickx J, et al. European Society of Anaesthesiology Task Force on Nitrous Oxide: A narrative review of its role in clinical practice. Br J Anaesth 2019;122(5):587-604. Available at: "https://www.bjanaesthesia.org/article/S0007-0912(19)30063-7/fulltext". Accessed May 27, 2023.
6. Galeotti A, Garret Bernardin A, D'Antò V, et al. Inhalation conscious sedation with nitrous oxide and oxygen as alternative to general anesthesia in precooperative, fearful, and disabled pediatric dental patients: A large survey on 688 working sessions. Biomed Res Int 2016;2016:7289310. Available at: "https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5056242/#B15". Accessed May 27, 2023.
7. Gupta N, Gupta A, Narayanan MRV. Current status of nitrous oxide use in pediatric patients. World J Clin Pediatr 2022;11(2):93-104. Available at: "https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8985494/". Accessed May 27, 2023.
8. Memè L, Gallusi G, Strappa E, Bambini F, Sampalmieri F. Conscious inhalation sedation with nitrous oxide and oxygen in children: A retrospective study. Appl Sci 2022;12(22):11852. Available at: "https://www.mdpi.com/2076-3417/12/22/11852". Accessed May 27, 2023.
9. Rossit M, Gil-Manich V, Ribera-Uribe JM. Success rate of nitrous oxide-oxygen procedural sedation in dental patients: Systematic review and meta-analysis. J Dent Anesth Pain Med 2021;21(6):527-45. Available at: "https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8637914/". Accessed May 27, 2023.
10. National Institute for Occupations Safety and Health. Criteria for a Recommended Standard Occupational Exposure to Waste Anesthetic Gases and Vapors. V. Development of Standard. Recommendations for a standard on waste anesthetic gases and vapors. March 1977. National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-140, 1977:105-110. Available at: "https://www.cdc.gov/niosh/pdfs/77-140d.pdf?id=10.26616/NIOSHPUB77140". Accessed May 27, 2023.
11. Varughese S, Ahmed R. Environmental and occupational considerations of anesthesia: A narrative review and update. Anesth Analg 2021;133(4):826-35. Available at: "https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8415729/". Accessed March 14, 2023.
12. Gratton TB. A review of the effects of trace concentrations of nitrous oxide on performance and related health problems in medical and dental personnel. J Environ Health 1982;45(1):24-8.
13. United States Department of Labor, Occupational Safety and Health Administration. Anesthetic Gases: Guidelines for Workplace Exposures. 1999. Revised 2000. Available at: "https://www.osha.gov/waste-anesthetic-gases/workplace-exposures-guidelines#C1". Accessed February 9, 2023.
14. Cohen EN. A survey of anesthetic health hazards among dentists. J Am Dent Assoc 1975;90(6):1291-6.
15. Cohen EN, Gift HC, Brown BW, et al. Occupational disease in dentistry and chronic exposure to trace anesthetic gases. J Am Dent Assoc 1980;101(1):21-31.
16. Rowland AS, Baird DD, Shore DL, et al. Reduced fertility among women employed as dental assistants exposed to high levels of nitrous oxide. N Engl J Med 1992;327(14):993-7.
17. Rowland AS, Baird DD, Shore DL, Weinberg CR, Savitz DA, Wilcox AJ. Nitrous oxide and spontaneous abortion in female dental assistants. Am J Epidemiol 1995;141(6):531-7.
18. Molina Aragonés JM, Ayora Ayora A, Barbara Ribalta A, et al. Occupational exposure to volatile anaesthetics: A systematic review. Occup Med (Lond) 2016;66(3):202-7. Available at: "https://academic.oup.com/occmed/article/66/3/202/2750583?login=false". Accessed February 9, 2023.
19. Hansen J, Schaal N, Juarez T, Woodlee C. Nitrous oxide exposure among dental personnel and comparison of active and passive sampling techniques. Ann Work Expo Health 2019;63(3):337-48. Available at: "https://academic.oup.com/annweh/article/63/3/337/5373585?login=false". Accessed February 9, 2023.
20. National Institute for Occupational Safety and Health. Health hazard evaluation report: Assessment of nitrous oxide exposures in a pediatric dentistry. Dacula, GA. By Achutan C, Radke M, Garcia A, Mead K, King B. Cincinnati, Ohio: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH HETA No. 2005-0157-3110. 2010:2. Available at: "https://www.cdc.gov/niosh/hhe/reports/pdfs/2005-0157-3110.pdf". Accessed February 9, 2023.

21. Zaffina S, Lembo M, Gilardi F, et al. Nitrous oxide occupational exposure in conscious sedation procedures in dental ambulatories: A pilot retrospective observational study in an Italian pediatric hospital. BMC Anesthesiol 2019;19(1):42. Available at: "https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6438021/". Accessed February 9, 2023.
22. Henry RJ, Primosch RE, Courts FJ. The effects of various dental procedures and patient behaviors upon nitrous oxide scavenger effectiveness. Pediatr Dent 1992;14(1): 19-25.
23. National Institute for Occupations Safety and Health. Criteria for a Recommended Standard Occupational Exposure to Waste Anesthetic Gases and Vapors. I. Recommendations for a standard on waste anesthetic gases and vapors. March 1977. National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-140, 1977:1-3. Available at: "https://www.cdc.gov/niosh/pdfs/77-140a.pdf?id=10.26616/NIOSHPUB77140". Accessed February 9, 2023.
24. National Institute for Occupational Safety and Health. Control of occupational exposure to N2O in the dental operatory. Whitcher CE, Zimmerman DC, Piziali RL. Cincinnati, Ohio: U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-171, 1977: 1-44. Abstract available at: "https://www2a.cdc.gov/nioshtic-2/BuildQyr.asp?s1=77%2D171&f1=%2A&Startyear=&Adv=0&terms=1&EndYear=&Limit=10000&sort=&D1=10&PageNo=1&RecNo=4&View=f&". Accessed May 27, 2023.
25. United States Department of Labor, Occupational Safety and Health Administration. OSHA Occupational Chemical Database: Nitrous Oxide. Updated June 3, 2022. Available at: "osha.gov/chemicaldata/4". Accessed May 27, 2023.
26. Occupational Safety and Health Administration Environmental Compliance Systems. What is the difference between a PEL, TLV and REL? Available at: "https://oecscomply.com/wp-content/uploads/2020/09/PEL-TLV-REL_2.pdf". Accessed February 9, 2023.
27. International Labour Organization, World Health Organization. Nitrous Oxide. ICSC:0067 (June 2015). Available at: "https://www.ilo.org/dyn/icsc/showcard.display?p_lang=en&p_card_id=0067&p_version=2". Accessed February 9, 2023.
28. Whitcher CE, Zimmerman DC, Tonn EM, Piziali RL: Control of occupational exposure to nitrous oxide in the dental operatory. J Am Dent Assoc 1977;95(4):763-76.
29. American Academy of Pediatric Dentistry. Use of nitrous oxide for pediatric dental patients. The Reference Manual of Pediatric Dentistry. Chicago, Ill.: American Academy of Pediatric Dentistry; 2023:393-400.
30. Rademaker AM, McGlothlin JD, Moenning E, Bagnoli M, Carlson G, Griffin C. Evaluation of two nitrous oxide scavenging systems using infrared thermography to visualize and control emissions. J Am Dent Assoc 2009; 140(2):190-9.
31. Chrysikopoulou A, Matheson P, Miles M, Shey Z, Houpt M. Effectiveness of two nitrous oxide scavenging nasal hoods during routine pediatric dental treatment. Pediatr Dent 2006;28(3):242-7.
32. Freilich MM, Alexander L, Sándor GKB, Judd P. Effectiveness of 2 scavenger mask systems for reducing exposure to nitrous oxide in a hospital-based pediatric dental clinic: A pilot study. J Can Dent Assoc 2007;73(7): 615-615d. Available at: "http://www.cda-adc.ca/jcda/vol-73/issue-7/615.pdf ". Accessed January 26, 2023.
33. Messeri A, Amore E, Dugheri S, et al. Occupational exposure to nitrous oxide during procedural pain control in children: A comparison of different inhalation techniques and scavenging systems. Pediatr Anaesth 2016;26(1): 919-25.
34. Primosch R, McLellan M, Jerrell G, Venezie R. Effect of scavenging on the psychomotor and cognitive function of subjects sedated with nitrous oxide and oxygen inhalation. Pediatr Dent 1997;19(8):480-3.
35. Henry RJ, Borganelli GN. High-volume aspiration as a supplemental scavenging method for reducing ambient nitrous oxide levels in the operatory: A laboratory study. Int J Paediatr Dent 1995;5(2):157-61.
36. American Dental Association. Dental best practices for nitrous oxide-oxygen use. November 29, 2021. Available at: "https://www.ada.org/resources/research/science-and-research-institute/oral-health-topics/nitrous-oxide". Accessed March 17, 2023.
37. Crouch KG, McGlothin JD, Johnston OE. A long-term study of the development of N_2O controls at a pediatric dental facility. AIHAJ 2000;61(5):753-6.
38. Guelmann M, Brackett R, Beavers N, Primosch RE. Effect of continuous versus interrupted administration of nitrous oxide-oxygen inhalation on behavior of anxious pediatric dental patients: A pilot study. J Clin Pediatr Dent 2012;37(1):77-82.
39. American Dental Association Council on Scientific Affairs, American Dental Association Council on Dental Practice. Nitrous oxide in the dental office. J Am Dent Assoc 1997;128(3):364-5.