



SIOI Policy on nitrous oxide/oxygen anxiolysis in Paediatric Dentistry



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Context

Dental anxiety in children is a prevalent issue that can hinder access to care and negatively affect oral health. As its impact extends beyond the patient to influence clinical outcomes and practitioner stress, effective management is essential. Nitrous oxide-oxygen inhalation sedation offers a safe and well-established solution, reducing anxiety and enhancing cooperation without resorting to general anaesthesia. This approach aligns with the principles of minimally invasive care, promoting a more positive and individualised treatment experience in paediatric dentistry.

Briefly

Safe Paediatric Sedation: N₂O/O₂ anxiolysis manages dental anxiety in healthy children (ASA I–II).

Clinical Integration: Works well with other behaviour techniques to enhance cooperation.

Target Population: Ideal for healthy children (ASA I–II); elective sedation technique of choice.

Administration Standards: Requires certified machines with ≥30% O₂; start with 40–50% N₂O.

Post-Procedure Care: Administer 100% O₂ for ≥5 minutes; discharge only after full recovery.

Consent & Guidelines: Informed parental consent essential; adherence to clinical protocols ensures safety and quality.

Training Perspective: Given its safety and simplicity, no extra postgraduate training is needed, per the Italian Society of Paediatric Dentistry.

KEYWORDS: nitrous oxide, oxygen, anxiolysis, analgesia, paediatric dentistry, SIOI policies.

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PURPOSE The Italian Society of Paediatric Dentistry (SIOI) is committed to encourage all dental practitioners to provide safe and updated prevention and treatment strategies for oral diseases in paediatric patients. SIOI promotes quality communication and information to parents and caregivers for prevention and awareness of oral diseases in the paediatric population. The purpose of this SIOI Policy is to provide dental professionals with comprehensive guidance on effective use of nitrous oxide/oxygen analgesia/anxiolysis for children, ensuring that treatment decisions are based on the latest and highest-quality scientific evidence.

METHODS This Policy is based on a review of current highest-quality literature, including systematic reviews, meta-analyses, recommendations, manuscripts and best practices published over the last 20 years. An extensive search was conducted using PubMed®/MEDLINE, including the following parameters: nitrous oxide, oxygen, anxiolysis, relative analgesia, dental fear, anxiety, child. Papers for review were chosen from the list of articles and manuscripts which met the criteria and from references, within the selected articles and manuscripts. Recommendations were also based upon expert and consensus opinion by experienced researchers and clinicians.

Introduction

SIOI recognises the importance of behaviour management in children undergoing dental treatment, to perform the best quality of dental care while achieving a positive experience and attitude. To obtain children's cooperation during dental treatment it is sometimes necessary to modify or influence their behaviour. Therefore, behaviour management techniques (BMTs) have been developed to facilitate communication with patients, while aiming to eliminate inappropriate behaviours [Veloso et al., 2023]. Nitrous oxide/oxygen inhalation, also referred to as N₂O/O₂, Relative Analgesia and as N₂O/O₂ analgesia/anxiolysis has been documented as a safe and effective mean of behaviour management. When used as a single agent and in concentration less than 50% nitrous oxide allows for diminution of pain and anxiety in a conscious patient, while entailing minimum risk [AAPD, 2024a]. Characteristics of an ideal sedative and analgesia agent would include the following: providing good sedation and analgesia, quick onset of action and rapid recovery upon discontinuation, preservation of the cardiovascular and respiratory status of the patient, amnesic features, no allergic reactions, irrelevant side effects, non-traumatic administration. Nitrous oxide has almost all the mentioned

properties, making it an ideal agent for procedural inhalation sedation and analgesia [Malamed, 2018]. The goals of nitrous oxide/oxygen anxiolysis technique are as follows: to reduce or eliminate anxiety, to reduce untoward movement and reaction to dental treatment, to enhance communication and patient cooperation, to increase tolerance for longer appointments, to reduce gagging, to raise the pain threshold during dental procedures [AAPD, 2024a; Morris and Clark 2020; Malamed, 2018; Arcari and Moscati, 2018; Veloso et al., 2023].

Discussion

Managing fear and anxiety in paediatric dental patients is critical to ensure a positive treatment experience and to prevent the long-term consequences of dental avoidance. Basic behavioural guidance techniques are fundamental in paediatric dentistry; nitrous oxide/oxygen anxiolysis is a basic BMT which may play an important role in facilitating quality dental treatment completion. Scientific evidence on the use of nitrous oxide/oxygen inhalation sedation is presented in this Policy.

General Considerations

Dental anxiety disorders, which decrease as the age increases [Cazares et al., 2020] are prevalent problems in dentistry and represent a barrier to dental care in children [Gozin et al., 2022]. Considering how closely related dental fear and poor oral health are, it is fundamental to reduce anxiety in children [Cosi et al., 2022]. The prevalence of dental fear and anxiety was found to vary widely from 10.0% to 29.3%, owing to differences in study design, sampling methods, type of instrument [questionnaires] used, and socioeconomic variables [Cianetti et al., 2017].

Various techniques have been proposed for behaviour guidance, ranging from basic non-pharmacological strategies to pharmacological interventions such as sedation and general anaesthesia [Quek et al., 2022]. Clinicians treating patients who present dental anxiety encounter time-consuming difficulties, increased fatigue and costs during their dental practice [Paglia, 2016] and the troublesome behaviour of children with dental fear is a major cause of stress for many paediatric dentists [Paglia et al., 2017]. Therefore, the dentist should be competent in the management of anxiety using both pharmacological and non-pharmacological BMTs, in order to treat each patient appropriately, according to age, guaranteeing the best therapeutic quality [Cianetti et al., 2017]. If the level of fear is incongruent with the circumstances and the patient is not able to tolerate the indicated dental therapy or presents with

disruptive behaviour, a sedative approach may be required [Ferrazzano et al., 2020].

Although each technique has its merits, the use of nitrous oxide-oxygen inhalation for the provision of paediatric dental treatment has long since been shown to be a safe and effective alternative to general anaesthetic [Walley et al., 2015]. Nitrous oxide-oxygen inhalation sedation has been widely used for decades as a safe and effective technique to reduce anxiety, improve cooperation, and ensure a more positive treatment experience. It is therefore important that clinicians have a good understanding of nitrous oxide/oxygen anxiety management technique to support effective decision making that leads to the best possible patient outcome. The majority of children respond well to treatment using nitrous oxide/oxygen inhalation sedation and it is a viable treatment option instead of GA and for those children who do not accept dental treatment under LA [Madouh et al., 2016]. A reduction in the use of general anaesthesia may be accomplished [Mourad et al., 2022]. It is appreciated by young children [Arcari et al., 2008] and parents [Al Zoubi et al., 2021]; growing parents' approval of pharmacological techniques has been observed [Patel et al., 2016, Boka et al., 2014].

Properties - Mechanism of Action

N₂O is a small and simple inorganic chemical molecule that has been used in clinical dentistry since the 19th century [Clark and Brunick, 2020] and it is frequently used in modern dentistry as minimal sedation for paediatric dental procedures. Nitrous oxide is a colorless, non-irritating gas that is stable at room temperature and ambient pressure which, in subanaesthetic concentrations produces only mild sedative, analgesic and anxiolytic effects without unconsciousness [Damia and Paglia, 2017]. N₂O produces "relative analgesia", a term defined by Harry Langa as a chemically induced altered psychological state which decreases or even eliminates the fear and pain of dental experience. For the Relative Analgesia (RA) technique, low concentrations of N₂O mixed with high concentrations of O₂ are administered to produce mild sedation and analgesia, while psychological reassurance is maintained. Nitrous oxide induces relaxation [Ferrazzano et al., 2020]; the patient remains conscious and cooperative with protective reflexes fully maintained, also experiencing a pleasant, floating sensation [Samir et al., 2015].

Nitrous oxide has a rapid onset and allows for quick recovery, making it a suitable choice for paediatric dental patients. The patient is asked to inhale a gas mixture consisting of low percentages of nitrous oxide and high percentage of oxygen [Tieri et al., 2023].

Nitrous oxide presents multiple mechanisms of action. It interacts with the central nervous system by modulating gamma-aminobutyric acid (GABA) receptors, either directly or indirectly, leading to an overall reduction in anxiety and pain perception. The analgesic effect involves neurological release of endogenous opioids, modulating nociceptive processing at the spinal level. Unlike deeper sedation techniques, nitrous oxide allows the patient to remain conscious, responsive, and in control of their protective reflexes. Because it is absorbed rapidly in the alveoli and eliminated through respiration,

its effects can be precisely controlled, allowing for rapid induction and recovery. Elimination occurs almost completely through the lungs, with no toxic accumulation in any organ or body district. Blood pressure is maintained, with advantage in treating patients who present cardiovascular system disorders [AAPD, 2024a]. Effectiveness of N₂O-O₂ inhalation sedation in raising the pain threshold and producing anxiety management in paediatric dental patients makes it the preferred pharmacological behaviour management technique [Samir et al., 2015].

The most important international scientific societies of paediatric dentistry, including the Italian Society of Paediatric Dentistry (SIOI), recommend the use of this technique as the first choice, to be preferred to other sedative techniques, when a form of sedation is indicated to restore oral health in children [Paglia and Beretta, 2021]. Differences between GA and N₂O/O₂ anxiety management are highlighted and summarised in Table 1.

Administration Technique

N₂O/O₂ flow is administered using a sedation machine (SM), -an inhalation medical device specifically designed for dentistry- which has multiple features to ensure precise gas percentage delivery. To prevent the delivery of hypoxic mixtures, the SM must meet specific safety requirements as follows:

- Nitrous oxide (N₂O) cannot be delivered without a minimum of 30% oxygen (O₂);
- N₂O concentration can never exceed 70%;
- SM must have a fail-safe system that stops N₂O delivery in absence of O₂ supply.

The procedure begins with a flow of 100% oxygen for 1-2 minutes to establish patient comfort and assess the child's ability to breathe through the nasal mask. Nitrous oxide is then gradually titrated, increasing in 5% increments until reaching the desired concentration at a flow rate appropriate to the child's necessity. In paediatric patients, N₂O can be also administered starting with concentrations between 40% and 50%, depending on individual clinical demand and patient response. During N₂O/O₂ administration the concentration of nitrous oxide should not routinely exceed 50% to decrease incidence of adverse events [Saxen, 2022].

Throughout the procedure, the patient remains conscious, responsive, and able to maintain airway reflexes [Ashley et al., 2021].

At the end of the procedure, 100% oxygen is given to the patient for at least 5 minutes to prevent complications. Before discharge, the patient must be assessed to confirm full recovery [Varughese et al., 2021].

Indications and Contraindications

Nitrous oxide-oxygen sedation is highly effective for managing mild to moderate dental anxiety, reducing stress, and improving cooperation in ASA I and ASA II paediatric patients. It is particularly beneficial for children who have difficulty tolerating routine dental procedures, those with a strong gag reflex, and patients requiring multiple restorations or extensive dental care. Moreover, it serves as a useful adjunct for children with special healthcare needs

	GA	N ₂ O/O ₂
Child's role	Passive/unconscious	Active/cooperative conscious
Protective reflexes	Absent	Present
Breathing	Respiratory assistance	Spontaneous breathing
Preliminary examinations	Laboratory tests and exams	Anamnesis, objective examination
Analgesia	Total	Partial, local anaesthesia may be indicated
Practitioner and location	Anesthetist, operating room	Dentist, dental office
Risks	Moderate	Minor. Mild and quickly reversible side effects
Discharge	Slow. Hospitalisation may be required	Fast. A few minutes after procedure

TAB. 1 Comparison between general anaesthesia -GA- and nitrous oxide/oxygen inhalation technique -N₂O/O₂- [Damia and Paglia, 2017].

Scavenging equipment	Scavenging systems will ensure proper N ₂ O remove during patient's exhalation
Patient Selection	Patients who cry, who are not able to breath through their nose or those who do not tolerate the nasal mask are not suitable candidates for N ₂ O/O ₂ inhalation technique
Titration	N ₂ O titration to the minimal effective dose will help lower N ₂ O ambient levels
Mask selection	A properly sized mask should be selected for each patient to minimise leakage
Sedation Machine periodic inspection	Equipment inspection will allow correct maintenance and replacement of damaged components
Fresh air intake	Clean outdoor air for dental operatory ventilation
Terminal oxygen supply	100% O ₂ delivered to the patient for 5 minutes upon termination of N ₂ O flow will significantly reduce N ₂ O ambient levels

TAB. 2 Recommendations for maintenance of N₂O lowest ambient levels.

who may otherwise require general anaesthesia for basic dental treatment. However, nitrous oxide is contraindicated in patients with acute upper respiratory infections, severe respiratory conditions such as uncontrolled asthma or chronic obstructive pulmonary disease, those with recent middle ear infection and patients with a recent ear, nose, throat or retinal surgery. Patients with a history of pneumothorax or metabolic disorders affecting vitamin B12 metabolism may also be at risk for complications. Nitrous oxide should be avoided in patients who present severe emotional disturbances and drug-related dependences, as nitrous oxide causes central nervous system depression and euphoria. Avoidance during the first trimester of pregnancy should be pursued due to potential effects on fetal development [AAPD, 2024a].

Additionally, pre-cooperative young children will breathe through their mouth, crying, screaming and moving about in the chair, thus negating the effect of N₂O. To be successful the patients must accept the nasal hood and be willing and able to breathe through their nose [Malamed, 2018].

Risks

Although nitrous oxide sedation is widely regarded as safe, certain risks must be considered: the most common adverse effects include nausea and vomiting. Fasting is not required for patients scheduled for nitrous oxide/oxygen analgesia/ anxiolysis [AAPD, 2024a]. However, a light snack may be suggested by the clinician a few hours before the inhalation appointment, as patients treated on an empty stomach are more susceptible to nausea/vomiting. Heavy meals preceding nitrous oxide/oxygen administration also are at higher risk for nausea and vomiting [Malamed, 2018].

Other side effects include oversedation, sweating, dysphoria, headache, dizziness, hallucination [AAPD, 2024a].

Diffusion hypoxia may occur due to rapid release of nitrous oxide from the blood stream into the alveoli, if 100% oxygen is not administered at the end of nitrous oxide inhalation for 5 or more minutes.

Occupational Health Hazards

Occupational exposure to ambient N₂O has been studied for decades, yet the effects of ambient N₂O exposure are still uncertain [AAPD, 2024b; Damia and Paglia, 2017]. The specific biologic issue of N₂O high concentration is the inactivation of methionine synthase, which is linked to vitamin B12 metabolism; B12 is necessary for DNA production and cellular reproduction. However, a recent systematic review reported that evidence is scarce and inconsistent regarding adverse effects caused by long-term exposure to small concentrations of N₂O (as dental workplace exposure) on health professionals [Molina et al., 2016].

Patient selection is an important consideration in reducing ambient N₂O levels. The major cause of N₂O contamination in the dental setting is from the patient crying and talking, therefore the clinician should make the verbal interaction with the patient as brief as possible [Malamed, 2018]. The dentist's exposure was found to be greater than the dental assistant [Hansen et al., 2023]. Introducing N₂O scavenge, sedation machine system maintenance, fresh outdoor air

exchange and other control measures have been effective in reducing ambient N₂O in the dental setting [Zaffina et al., 2023]. Therefore, to maintain the lowest environmental level of N₂O in the dental site it is necessary to adopt appropriate measures, which are summarised in Table 2.

Benefits

The demand for nitrous oxide/oxygen inhalation sedation far exceeds its provision in Italian dental practice even though the advantages of nitrous oxide/oxygen inhalation in paediatric dentistry are well-documented. Its primary benefit is its ability to create a calm and cooperative environment, making it easier to complete dental procedures efficiently and with minimal distress to the patient. Achieving wellness for both the patient and the clinician is an important benefit in the use of nitrous oxide/oxygen technique during dental care for children; moreover, it allows improved communication between the young patient and the dental team. N₂O-O₂ inhalation also aims at analgesia by raising the pain threshold of children during dental treatment with almost negligible adverse events [Arcari and Moscati, 2018]. Nitrous oxide is easily titrated. The titratability of nitrous oxide allows practitioners to adjust sedation levels as needed, ensuring individualised administration. Additionally, the rapid onset and recovery enable patients to return to normal activities almost immediately after treatment, within a few minutes [Malamed, 2018]. The use of inhalation sedation with nitrous oxide/oxygen has been shown to be beneficial in the reduction of dental anxiety [Ferrazzano et al., 2020]. When used in accordance with recommended techniques and patient selection criteria (ASA I and ASA II), nitrous oxide/oxygen anxiolysis exhibits a high degree of efficacy and patient safety in the clinical dental setting [AAPD, 2024b].

Factors to consider before using N₂O/O₂ anxiolysis for paediatric patients include: medical and dental history, dental treatment needed, physical and emotional development, alternative behaviour guidance strategies [AAPD, 2024a]. Informed consent must be obtained from parents or legal guardians before nitrous oxide/oxygen administration, with a clear explanation of the procedure, benefits, risks, and available alternatives.

Throughout the entire procedure the patient must be observed by the clinician and the dental team. The inhalation sedation unit should be also observed during the administration. The level of sedation sought with N₂O/O₂ is such that communication between the practitioner and the patient is achieved: the patient should be able to respond to any request or questions posed [Malamed, 2018]. No technological monitoring is required; pulse oximetry is not mandatory when nitrous oxide gas is being administered for minimal sedation to a healthy patient having no pre-existing diseases/illness [Gupta et al., 2022]. When nitrous oxide concentration is maintained at 50% or less, ventilatory and cardiovascular functions are generally unaffected; however, nitrous oxide effect may be more profound. Therefore, clinicians should have the skills to manage moderate sedation; training and certification in basic life support are required. Administration of 100% for at least 5 minutes should be performed, once the nitrous oxide flow is terminated [AAPD, 2024a].

Policy statement

- Nitrous oxide/oxygen (N₂O/O₂) analgesia/anoxiolysis is a safe and effective basic behaviour guidance technique for managing dental anxiety in children. N₂O/O₂ anoxiolysis may be easily integrated to other BMTs to improve patient cooperation and maximise treatment outcomes.
- N₂O/O₂ anoxiolysis is the elective sedation technique for healthy paediatric patients, classified in American Society of Anesthesiologists (ASA) Physical Status Classification I and II.
- Administration of N₂O/O₂ in the dental setting must occur only through the use of sedation machines. These inhalation devices are specialised medical/dental equipment which are designed to ensure precise gas delivery and patient safety. Sedation machines must have the capacity for delivering 100% and never less than 30% O₂ concentration.
- The recommended technique of N₂O/O₂ administration in paediatric patients starts with 40% to 50% N₂O concentration to promote fast adaptation, enhance sedation efficacy, and ensure both patient safety and comfort.
- Instrumental monitoring of the patient is not required during the procedure. One hundred percent oxygen must be administered for at least 5 minutes after discontinuing N₂O flow to avoid complications and to reduce ambient N₂O levels. The patient must return to pre-treatment responsiveness before discharge.
- Informed consent must be obtained, providing a clear explanation of the procedure, benefits, risks, and available alternatives to parents/ caregivers.
- Paediatric dental practitioners are encouraged to integrate N₂O/O₂ analgesia/anoxiolysis into their clinical practice, following national and international guidelines to uphold the highest quality standards of patient care and safety.
- Given the safety of nitrous oxide/oxygen anoxiolysis technique and the rapid learning curve for the practitioner, it is opinion of the Italian Society of Paediatric Dentistry that no additional postgraduate training should be required for its implementation in the dental practice.

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