Rationale for Using Nitrous Oxide in Pediatric Dentistry

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Contents

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Learning Objectives

1. Comprehending fear and anxiety in children which forms the basis for using nitrous oxide in children
2. Understanding the purpose of using nitrous oxide in children which will help in increasing its use in children
3. Studying about the indications of using nitrous oxide in children which assists in case selection
4. Knowing contraindications which will help in making this technique more efficacious and safe
5. Realizing the advantages of this technique over other modes of sedation
6. Appreciating the disadvantages of this technique in order to know its limitations

A visit to a dental clinic is always considered to be nerve-racking whether for adults or children. The "smell, the sounds", and the general atmosphere all add up to create an atmosphere which is not exactly perceived to be pleasant by most people. If you add crying children and stressed out parents to the mix, as in case with pediatric dental offices, then the situation becomes even more complex. This means that pediatric dentistry can be demanding for all the people involved and most importantly for child patients. Understanding the basics of fear and anxiety is a stepping stone towards the successful use of nitrous oxide in children as a behavior management tool. The purpose of using nitrous oxide should be clear to the pediatric dentists, in order to ensure that this technique is practiced effectively and efficaciously. It is more of a behavior guidance tool rather than a sedative tool. In this chapter, the indications and contraindications of using nitrous oxide in children shall be discussed as well as the advantages and disadvantages of its use in a pediatric dental office. A thorough knowledge about these will instill confidence in the pediatric dentists about its use in majority of their child patients.

1.1 Understanding Fear and Anxiety

The knowledge and understanding of fear and anxiety not only lays the foundation of our ability to provide the best possible care for children but more importantly allows us to establish a healthy and long-term relationship with them. It helps dentists recognize the signs of fear and anxiety, understand the underlying etiology, and enable them in developing a strategy to interact with such children. It is only after a thorough understanding of fear and anxiety that a dentist can use basic behavior guidance techniques individualized to each pediatric patient and introduce nitrous oxide in an effective manner.

1.1.1 What Is Fear?

Fear is a natural part of a child's development. Overcoming fear helps a child successfully engage and overcome a difficult situation. A child who is able to overcome a fearful situation develops a sense of achievement and becomes more confident. On the other hand, a child who gets overwhelmed by fear often chooses to "run away from the situation." In our case, it means leaving the operatory or if he chooses to stay, he does not allow the dentist to examine or treat him. Such a patient continues to remain "scared of dentists" and becomes more insecure as time passes. This perpetuates future anxiety and reluctance in accepting dental care.

Fear is defined as an unpleasant emotional response to a real or perceived immediate external threat or danger [1]. Fear comprises of psychological and psychophysiological responses. In simple terms, fear is the emotion one experiences, when there is an imminent threat of harm [2]. Fear is a protective emotion and integral to human experience. Fear is caused by specific stimuli in a context-dependent way [3].

Inability to handle a difficult situation leads to the development of fear.

1.1.2 Ages and Stages of Fear

Fears vary across ages and stages of child development (Fig. 1.1). Typically, fears vary in frequency, intensity, and duration. Fears wax and wane as a child grows; they also tend to differ based on the objects which evoke them in an age-specific and transitory way [4]. Children's fears at various age groups has been detailed in Appendix I. Knowledge about age-specific fears can be useful for the dentists when dealing with children. For eg: In a dental office, separation from parents should not be done for preschoolers as it may induce fear.

1.1.3 Development and Physiology of Fear

The neurobiology of fear remains in its infancy. From an evolutionary perspective, fear is a protective mechanism and enables one to respond appropriately when faced with danger or harm. Fear is considered as an innate function of the subcortical brain, and the amygdala is referred to as the hub of the fear circuit [2]. The role of the amygdala in processing and expressing fear is summarized in Fig. 1.2.

Amygdala is the core of fear circuit in the brain.

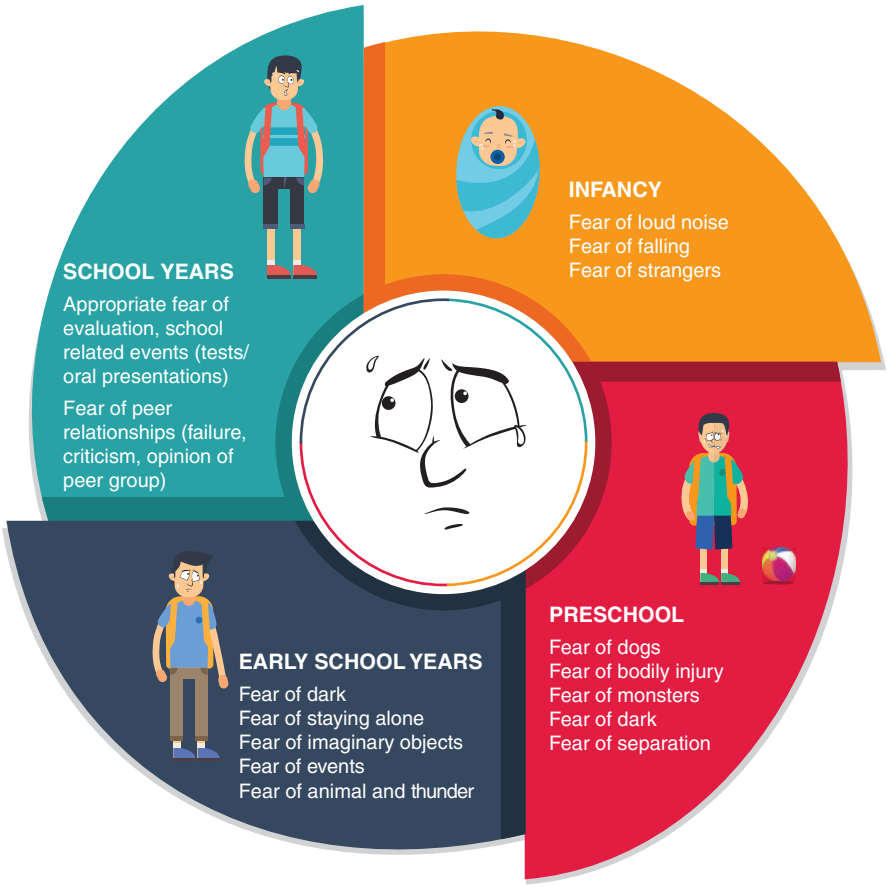

Fig. 1.1 Different kinds of fear at various age groups in a growing child

A child's fear has been explained by several theories. It may be related to the emotional involvement with their parents [5, 6] or may be a conditioned response involving learning, unlearning, and modification of fear through environmental experiences. Gesell states that children [7] go through a series of fears as they mature. Jeffrey Derevensky stated that children's fears are not unrealistic or imaginary [8].

Fear in children is mostly learned through experiences or taught by parents, teachers, siblings, or friends.

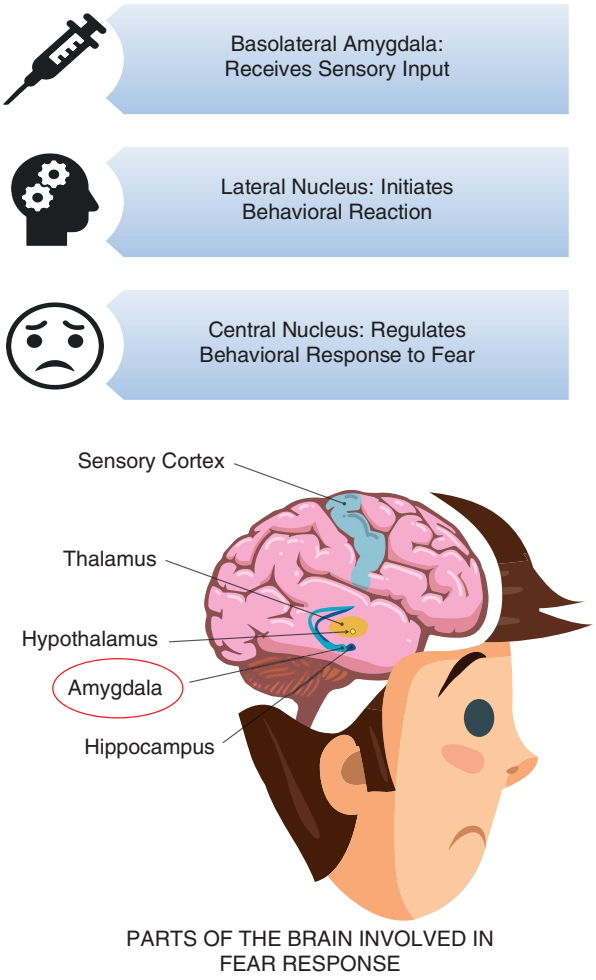

Fig. 1.2 Location and Role of the amygdala in processing and expressing response to fear

1.1.4 Responses to Fear

Stimuli that evoke fear unravel a complex cascade of behavioral, autonomic, endocrine, and cognitive responses. Broadly speaking, fear results in inner feeling/cognitive response, outer behavioral expression, and accompanying physiological changes [4]. The responses to fear are summarized in Fig. 1.3.

Inner feeling/cognitive Response: Negative statements or statements regarding possible danger from fearful situation (e.g., "I feel scared," "The dog will bite me!").

Behavioral Response: Avoidance or escape from the fearful situation, crying, clinging to parents, physical combativeness. The dentist usually has to manage this behavioral response while trying to deliver dental care to a fearful child (Figs. 1.4, 1.5, and 1.6).

A clinician can recognize a fearful child based on behavioral responses.

Physiological: Increased heart rate and respiratory rate, sweating, dryness of mouth, trembling, shaking, changes in respiration.

The emotional response to fear varies from a person to person and is more subjective. The subjective emotional reaction translates to behavioral changes manifesting in characteristic facial expressions, flight, fright, freeze, and/or avoidance [9]. In the long run, stimuli causing fear also lead to the development of particular adaptive behaviors within an individual to avoid or cope with the threat [3].

Fig. 1.3 Different responses to fear

Fig. 1.4 A crying child

Fig. 1.5 A fearful child clinging to mother and covering his mouth

Fig. 1.6 A fearful child wanting to go out of the operatory

1.1.5 Types of Fear

Since fear is evolutionarily related to prevention from harm, there are innate fears, which occur in children, irrespective of their past experiences. Innate fear is not conditioned. It drives the individual's defense when faced by a threat, much like the flight or fright reaction of an animal when it sights its predator. However, an individual's lifetime experiences also shape the development of other fears. Over the course of life, individuals acquire fears. Figure 1.7 provides a visualization of classification of fear into innate and acquired fears in children [10]. The acquired fears are discussed below as conditioned, objective, and subjective fears.

Conditioned fear is the development of fear responses according to the classic Pavlovian conditioning. Classic fear conditioning is described in a historical experiment where a little boy was presented with a white rabbit. At the same time, a suspended steel bar was struck with a hammer to produce a frightening loud noise. The noise caused the boy to tremble and cry. After several pairings of the white rabbit and the noise, the little boy became visibly upset at the sight of the rabbit alone. He also generalized his conditioned emotional reaction to other white, furry objects [11, 12]. Such experiments would no longer be possible to conduct ethically.

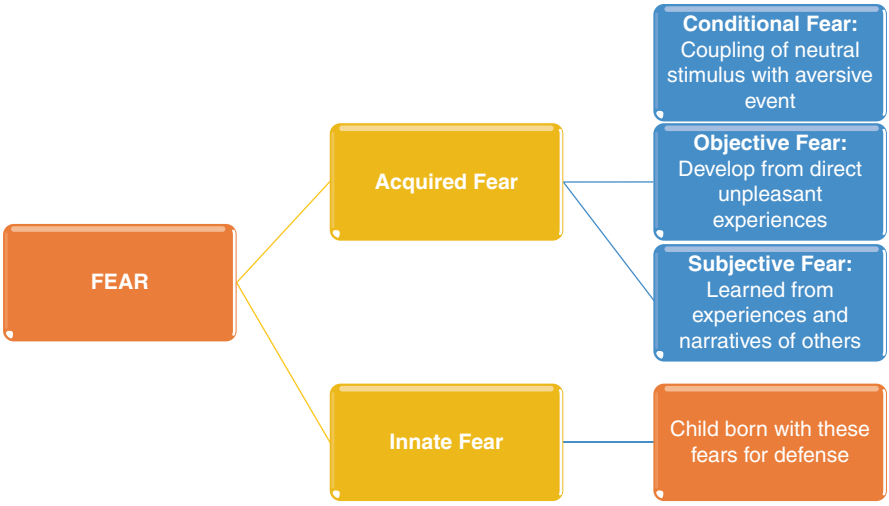

Fig. 1.7 Types of fear and their acquisition in children

However, the implications of conditioned fear in pediatric dentistry are significant. In the dental setting, an example of conditioned fear is the use of topical anesthesia prior to local anesthetic injection. During the first appointment, the child "learns" that the injection follows the application of topical anesthetic. During the second appointment, the child is conditioned to expect the injection after the application of topical anesthetic and may become fearful immediately after the application of topical anesthesia.

Objective fears develop based on one's own experiences. General impatience on part of the dentist while treating a child or lack of clinical skills may instill fear or anxiety in children [13]. An example is the child with an acute dental abscess who may have had a difficult extraction. Should this child need another extraction in the future, he/she will likely have a fear of extraction based on their direct experience at the previous dental visit. In fact, unbearable pain at their first visit to a dentist is a predictor of children developing long-term anxiety and apprehension towards dentists and dental treatment [14].

A dentist's manner of communication with a child, patience, clinical skills, and use of other behavior management techniques can help in reducing acquired fear in a child.

On the other hand, subjective fear develops based on the experiences or narratives of others. An example would be a child who hears negative feedback from a sibling about the dental treatment. A child's fear can also be initiated on hearing negative words about dental experiences from parents. Many a times, parents tell their children casually that "if you don't brush well, you will end up with a dentist

pulling out your teeth." The child now may be fearful at his/her own first dental appointment based on indirect experience or comments of somebody else (child may think that the dentist's job is to pull out teeth). This is similar to developing high levels of fear for a friendly animal for which parents have told threatening narratives to their child.

Mothers who are scared of dentists, often have children who are anxious and fearful about the same [15] and is another example of subjective fear in children.

It has been found that subjective fears are stronger determinants of dental fears in children than objective fears.

Classification of dental fears into four groups has been carried out by the Seattle system (Table 1.1) (Milgrom 1985) [16]

1.1.6 Levels of Fear

Humans and other species have developed fear as a protective adaptation for survival in response to danger. For most of us, the level of fear is commensurate with the level of threat, and fear response is a dynamic process, adapting to the severity of the threat with effective coping skills. An example is an individual who is fearful of dental procedures, yet he/she decides to receive dental care because the benefits of dental treatment outweigh the threat from the procedure. However, for others, fear is disproportionate to the threat. When fear interferes with normal functions, it leads to maladaptive behaviors, such as avoidance. An example is a child who is extremely fearful of dental procedures and hence avoids dental care until the last moment; this could adversely influence treatment, as a restorable tooth may become non-restorable due to disease progression.

1.1.7 Strategies of Dealing with Fear

Clinicians should be well versed with the developmental aspects of children's fear which are age and stage appropriate [7]. Some important clinically applicable concepts are as follows:

Table 1.1 Table showing types of dental fear (Milgrom 1985)

Type I	Conditioned fear	I am afraid of things that dentists do such as needles, sound, and smell
Type II	Fear of somatic reactions	I am afraid of fainting
Type III	Generally fearful	I am just scared
Type IV	Distrust of dental personnel	I don't trust dentists

- Never make fun of a child's fear.
- Positive reinforcement for a child's good behavior. Ending the dental appointment on a positive endnote enables a child to remember something positive, even about a difficult dental appointment. Constantly highlighting desired behavior can be a much more effective way of promoting the desired behavior and enhancing a child's confidence (Fig. 1.8).
- Try to be supportive and empathetic while talking to a fearful child (Fig. 1.9).
- Help child explore strategies to overcome their fears. Breathing exercises, visual imagery, art therapy, music, and suggestive hypnosis are examples of techniques which can be implemented in the dental clinic (Fig. 1.10).

A dentist should always make an effort to encourage the child to talk about their fear and its associated feelings.

Three categories of treatment to enable a child overcome dental fear are as follows [7]:

1. *Behavioral procedures*
   - Systematic desensitization
   - Modeling (Fig. 1.11)
   - Contingency management

Fig. 1.8 Positive reinforcement—praising child verbally

Fig. 1.9 Communicating in a supportive and empathetic manner while talking to a fearful child

Fig. 1.10 Using music to overcome a child's fear

Fig. 1.11 Modeling being done on parent to enable child overcome fear

2. *Cognitive behavioral interventions*

   It is a structured and brief psychological treatment based on a combination of psychoeducation, exposure, and homework exercises [17].

   It is based on changing distorted thinking and dysfunctional behavior. Clinicians should help children learn to identify their triggers, understand how anxiety affects their behavior, and how to replace distorted thoughts using cognitive reframing. Children are taught to replace negative thoughts with positive ones and separate realistic thoughts from unrealistic ones.
3. *Behavioral family interventions*

   This requires involvement of the family, especially the parents. The process involves identifying the problem, trigger for anxiety, and finding a possible solution. It involves stepwise achievement of goals. Positive reinforcement is an integral part of this. Parents need to allocate specific time during the day for this intervention.

1.1.8 Anxiety

Often, the terms fear and anxiety are used loosely or interchangeably. However, while fear is a phasic and transient response to an imminent or immediate threatening stimulus, anxiety is a sustained tonic state, based on the prediction of a threatening stimulus. The term anxiety is used to describe the feeling which occurs when the source of harm is either uncertain or distant in time or space. An individual's emotional response to anxiety and to fear is similar. The difference in fear and anxiety is illustrated in Fig. 1.12.

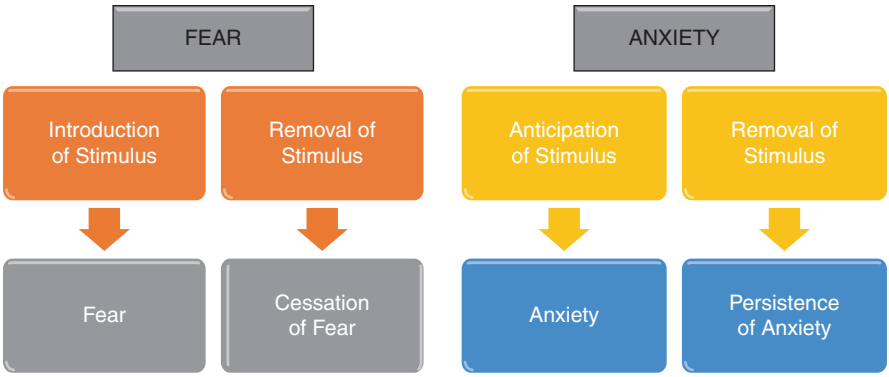

Fig. 1.12 Figure illustrating difference in fear and anxiety

A patient is dentally anxious when he feels that getting dental treatment will result in a negative outcome, and moreover he feels that if and when that happens he will not be able to control the outcome [18]. Dental anxiety has been attributed to factors such as personality characteristics, traumatic or painful past dental experiences in childhood (conditioned experiences), learned attitude towards dental care from fearful family members or peers, perception of body image, fear of bodily injury, coping styles, and pain reactivity [19].

Clinical anxiety in a child regarding a dental visit is a strong predictor of uncooperative behavior [14].

An important distinction between fear and anxiety is that fear is short lived and subsides after the threat or danger passes, while anxiety does not dispel as quickly.

There are various reasons for anxiety in children, as listed below [20]:

- Temperamental disposition
- Physical illness or disability
- Family problems

(A Disagreement between parents, recent parental divorce, parental illness, parents seeking reassurance from children, and parents using excessive threats to control their condition.)

- School/academic worries
- Problems with friends, social circles, and activities out of school

Temperament is a distinct personality of a child. It is an inborn trait which reflects the approach of a child towards the world. Children with different temperaments

will have different approaches towards their visit to a dental practice and their acceptability of dental treatment.

Thomas and Chess (1987, 1991) [21] categorized children into three clusters of temperament.

1. ***Easy***—Child is usually in positive mood and adapts easily to new experiences.
2. ***Difficult***—Child reacts negatively, cries frequently, and does not accept new situations easily.
3. ***Slow to warm up***—Child has low activity level and takes time to get adapted to new circumstances.

Rothbart et al. [22] develop Children's Behavior Questionnaire (CBQ) and its derivative Children's Behavior Questionnaire Short Form (CBQ-SF) which serves as an aid to evaluate child's temperament. As per this scale, children with easy temperament which includes children with high effort control (can easily stop an activity when he or she is told "no"), high soothability (easy to soothe when the child gets upset), and low frustration (does not become angry when he or she is asked to go to bed), low activity, and impulsivity (is not in a hurry to get from one place to another or rushing into an activity without thinking about it) will show more success with nitrous oxide sedation.

The physical manifestations of anxiety in children are listed in Table 1.2.

1.1.9 Phobia

Phobia is different from fear in that it is out of proportion, unreasonable, and persistent [23]. Dental phobia is a severe type of dental anxiety which is characterized by marked and persistent anxiety in relation to discernible dental situations/objects (e.g., injections, high-speed handpiece) or to dental situations in general. Dental anxiety and dental phobia represent different points on a continuum, varying from mild dental anxiety on one end to dental phobia on the extreme end of the continuum [24, 25].

> Dental phobia is an extreme form of dental anxiety.

Table 1.2 Physical signs of anxiety in children presenting for a dental appointment

Physical signs of dental anxiety in children
Hiding behind parents
Crying without any reason, screaming, or shivering (Fig. 1.13a)
Not sitting idly
Not making eye contact with the clinician (Fig. 1.13b)
Wanting to use the washroom
Angry or aggressive
Pulling parents out of the clinic

Fig. 1.13 (**a**) Anxious child crying without reason. (**b**) Anxious child not making eye contact with the clinician

1.1.10 Dental Fear and Anxiety in Children

Dental fear and anxiety have been recognized as a public health dilemma in many countries [18, 26].

> Dental fear and anxiety eventually lead to disease progression and exacerbation of the underlying dental problem due to avoidance of dental visits.

Fear of pain is an important predictor of dental anxiety [18]. The nature of fear prominent in a child's life corresponds to the child's age, cognitive ability, and stage of development [18]. In a pre-school child, attachment and separation anxiety play an important role. These children are less likely to become anxious if their parent and favorite toy accompany them into the dental operatory. In children older than 8 years of age, the fear of bodily injury is prominent. The fear of extraction is exaggerated in children in this age group. Teenagers manifest fear of dental treatment, likely due to issues of control and autonomy [18]. Most of these fears in children decrease or disappear as they grow older due to cognitive development and learning appropriate coping skills [18, 26]. Indeed, the prevalence of dental fear and anxiety is higher in younger children [26].

The pooled prevalence of dental fear in children across different countries varies between 10 and 20% [26]. The prevalence and level of dental fear and anxiety in Northern European pediatric populations are lower than in other geographic areas such as Southern Europe, Asia, and the USA. This implies that cultural factors influence dental fear and anxiety. While fear and anxiety in other contexts are socially unacceptable, dental fear is widely accepted and carries little social stigma [27]. Dental fear and anxiety are higher in girls than in boys [26].

Fear of dental treatment in children results in treatment difficulties [18]. Children with dental fear and anxiety exhibit behavioral problems, which can result in a stressful and unpleasant experience for the child, the parents, and the treating dental practitioner [24]. Such behavioral problems are often related to dental factors such as previous negative treatment experiences, particularly extraction, restorative procedures, and injection, which cause the most negative emotional load [18]. Conditioning is an important contributor to dental fear in children of 5–11 years of age [28]. Individuals with dental fear and anxiety have a high likelihood of cancelling dental appointments or failing to show up for scheduled dental appointments [24].

Dental fear leads to avoidance of treatment and high dental anxiety leads to poor oral health-related quality of life.

1.1.11 Etiology of Dental Fear in Children

Dental fear in children can be traced to five basic factors which play a role in its etiology. Dentists treating children should understand the underlying cause of fear as the basis of the uncooperative/fearful behavior exhibited by the child in the dental clinic [29]. These basic root causes of dental fears are summarized in Fig. 1.14.

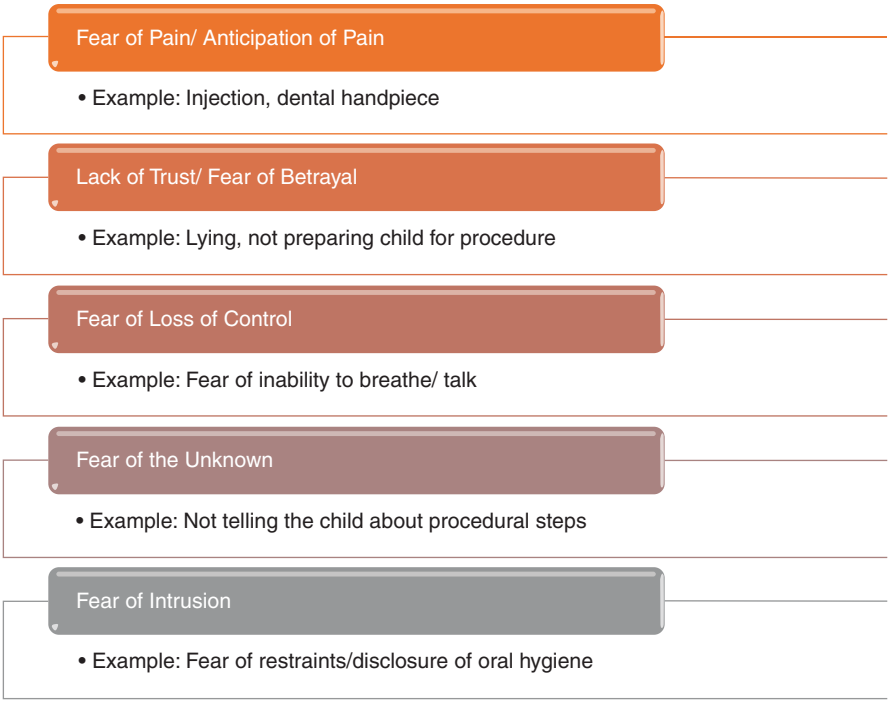

Fig. 1.14 Etiology of fearful behaviors by children during dental appointments

Fear of Pain or Its Anticipation

Dental fear is related to anticipated pain or misinterpreted pain. A logical explanation to the child that pain is different from touch or pressure can help the child in dissociating anticipated or misinterpreted pain from fear. For example, if the child complains of pain even after administering local anesthesia, then use of a probe, to let the child feel the difference in anesthetized and non-anesthetized area, assures the child that he/she will not experience pain.

Lack of Trust or Fear of Betrayal

Trust of the dentist is an important factor in dental fear among adults. However, there is no evidence-based data to demonstrate this in children [29]. Conventional wisdom and classic child psychology literature support building trust between the child and the dentist as the building block to successful dental appointments. Lack of trust in a child may be due to a previous negative experience with a dentist, or medical personnel, and/or learned from behavior/statements of parents, siblings, or peers.

Mistrust can be reduced by proper and honest communication with children. TLC or "tender loving care" is empathetic non-judgmental communication with the child, acknowledging the child's feelings. This mistrust can be reduced by asking the child about his/her feelings. The dentist should ask open-ended questions without words with negative connotations. Therefore, instead of asking the child "are you feeling scared?", the dentist can ask "how are you feeling today?". If the child responds "I am scared," the dentist can ask further open-ended questions such as "can you tell me more about why are you feeling scared today" or "can you tell what makes you scared." This will give the child an opportunity to explain all possible things, which may be a person, a situation, or some objects like a dental explorer which generate fear in his/her mind. To establish trust, it is important that the dentist addresses the matter that the child has identified as the source of distress. Removing or mitigating the stimuli will help the child develop faith and trust in dentist.

> Understanding etiology of fearful behavior can help a dentist form a strategy to deal with a child's fear.

Fear of Loss of Control

Children are fearful that when they open their mouth, the dentist would be in full control of them and they won't be able to stop the dentist in case of any threat to them.

This perceived control can be achieved through tell-show-do technique, offering decisional control (letting the child decide which tooth to polish first or performing polishing only till count of 5) and offering control over noxious stimuli (allowing the child to raise a hand in case of any pain or threat). These techniques are dependent on the cognitive development of a child.

Fear of the Unknown

This fear usually develops when the information is transmitted to the child in an inappropriate manner or certain words are used which may be misleading. An

example is, saying "It will not hurt" or "No injection will be given." Such statements leave ambiguous hints for an anxious child that something is probably going to hurt, or an injection is going to be given. Such statements create misinformation in the mind of an already anxious child, that the dentist may have other "unknown" things which he/she may use during the dental appointment.

Fear of the unknown can be reduced by utilizing the tell-show-do technique. The dentist should explain and show the child in a step-by-step manner, about the upcoming procedure. The child should be shown the instruments/devices used in that procedure. An example of effective tell-show-do technique is when the dentist tells the child "Today I want to count how many teeth you have using a small mirror," then the dentist shows the mirror, let the child feel the mirror in his/her hand. The dentist can also incorporate modeling on parents/siblings or other children in the clinic by using a mirror to count their teeth. This will make the child understand what he/she is required to do and what instruments will be used for that procedure.

Before performing an oral prophylaxis, a child is shown the slow-speed handpiece with a disposable brush and how the slow-speed handpiece runs. Then a small demonstration is shown on child's finger which will help make the child familiar with the sound and the vibrations on the finger. Then the prophylaxis can be carried out in the child's mouth.

Fear of Intrusion

This kind of fear involves impinging on "personal space" or "personal habits" of a child. A child's mouth, face, and body are considered personal space, and child's eating habits and oral hygiene habits are personal habits. Fear of intrusion is considered as the most difficult part to handle or address while managing a fearful child.

A child may be fearful of dentist putting instruments in his/her mouth (intruding into the personal space of a child) or being surrounded by dentist and assistants. Child may also be fearful of the dentist knowing about his/her improper brushing or eating habits. It is important for the entire dental team to remain non-judgmental of a child's dental status.

These five etiologic factors for fear of dentistry in children, usual reactions by children, and some suggested scripts for the dentist are listed in Table 1.3.

1.1.12 Implications of Dental Fear and Anxiety in Children

There is an increasing evidence for relationship between anxiety and pain. Fear of pain is a common phenomenon seen in children visiting pediatric dental practice. Children who are anxious are more likely to complain of pain. This contributes to pain-related avoidance which may further aggravate pain and thereby strengthening avoidance. It has also been found that anxiety has a direct relationship with the intensity of pain experienced by a child [30].

Table 1.3 Examples of etiology of fear and dentist's response

Child's reaction/ response	Fear factor	Dentist's response
"It will hurt"/"this is painful"	Fear of pain or its anticipation	I don't want to hurt you. You may feel some other sensations like pressure, vibration. But still, if you raise your left hand, I will stop immediately
"I know the dentist will put an injection" "I know you will drill my teeth"	Lack of trust/ betrayal	Implement tell-show-do technique to explain what a child can expect or experience. Assure the child that there will be no surprises
"I will faint"/"I won't be able to breathe"	Fear of loss of control	Let's practice taking deep breaths to make your belly-button move. You can keep doing this while I check your teeth. I have a thirsty straw to remove the water and spit from your mouth so that you feel comfortable
"I am just scared"	Fear of unknown	Thank you for telling me how you feel! If you can tell me what scares you, I can let you play with it, and then you will know that there is nothing scary about it. Implement desensitization and tell-show-do
"Don't hold my hands"/"I know I have bad teeth"	Fear of intrusion	When you move your hands, they can hurt me or my assistant. There are also some instruments here, which are sharp and may hurt your hands. If you keep your hands on your belly-button, we do not need to hold them Everybody comes to the dentist to get their teeth cleaned. That does not mean you have bad teeth. But I can certainly make your teeth very clean and healthy

Nitrous oxide has a major role in breaking this vicious cycle by reducing anxiety in a child. Once the anxiety is reduced, child's behavior is improved and the child is willing to accept the dental treatment.

Dental fear and anxiety elicit within the child an urgent need to escape from the dentist [2]. However, since the child is not physically able to escape the dental clinic, he/she starts exhibiting intense emotional responses. These vary from withdrawal, crying, screaming, and not opening the mouth to various levels of physical resistance. An important implication of dental fear and anxiety in children is uncooperative behavior in the dental clinic, which makes delivery of safe and quality dental treatment challenging. Dental anxiety is an important predictor of children's behavior in the dental setting, and there are strong associations between dental anxiety and perceived uncooperative and problem behaviors [31–33]. Uncooperative behavior of children in dental practice creates occupational stress in the dental staff. Stressful moments can also cause moments of discord between the dental professionals and the parents [34].

The sight of a needle and the sound of a dental handpiece are associated with causing highest anxiety in children [35, 36]. Higher levels of dental anxiety have been associated with an increased incidence of dental caries in children [37–39].

Parents who consistently fail to take their children to the dentist report that their children's dental anxiety is one of the influencing factors for their avoidance

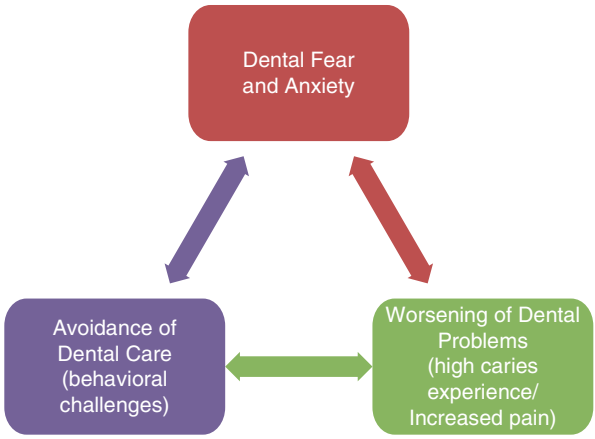

Fig. 1.15 Cycle of dental treatment needs and dental fear and anxiety

behavior [40]. Dental anxiety in children shapes their adult dental behaviors. Research has found that there may be long-term oral health implications resulting from children's dental anxiety, as dentally anxious children are more likely to be symptomatic, rather than proactive, users of dental services in adulthood [41]. The relationship between dental anxiety and dental avoidance is a vicious cycle which exacerbates the unmet dental need (Fig. 1.15). Dental fear and anxiety leads to avoidance of dental treatment. Addressing dental fear and anxiety will prevent treatment avoidance [25]. Besides, impact on dental care, dental fear, and anxiety may also cause sleep disorders, thereby affecting daily life of a child. It can thereby have an impact on the psychosocial functioning of a child.

Dental fear and anxiety can start a vicious cycle of avoidance and worsening of dental problems such as pain in teeth, which further enhances fear and anxiety.

Dental anxiety in children has financial implications. When advanced behavior guidance techniques, or referral to a pediatric dentist, are necessary to provide dental treatment for anxious children, additional fees and time are direct and indirect costs incurred to the parents.

Dental anxiety in young children influences their pain perception and pain threshold. Research has shown that young children with a low level of dental anxiety show a sensitized reaction trend for self-reported pain over two sequential dental visits, whereas young children with a high level of dental anxiety reported the most pain on the first treatment session [38]. Pain intensity experiences in children, particularly children under 14 years of age, are enhanced by higher dental anxiety [42].

Dental anxiety increases pain perception and pain exaggerates dental anxiety.

Table 1.4 Basic behavior guidance techniques for pediatric patients [43]

Technique	Description
Communication and communicative guidance	Active and reflective listening to establish rapport, trust, and comfort
Positive pre-visit imagery	Images are shown to children that demonstrate a positive, child-friendly dental environment
Direct observation and modeling	Watching a patient or video that demonstrates desirable dental behaviors
Tell-show-do	Use of age appropriate phrases to tell the child about the dental procedure, demonstration of the dental procedure, and completion of the dental procedure without deviations from assured steps
Ask-tell-ask	Ask the child about the feeling towards planned dental care, explain the treatment planned in age appropriate language, and ask the child again about how he/she feels about the planned care
Voice control	A deliberate alteration of volume, tone, or pace of the dentist's voice to obtain the child's attention and direct behavior
Nonverbal communication	Reinforcement and guidance of behavior through the dentist's facial expressions, body language, and appropriate physical contact
Positive reinforcement and descriptive praise	Reward desired behaviors in the child with positive social reinforcers, such as verbal praise and facial expressions
Distraction	Diverting the child's focus away from a perceived unpleasant procedure
Parental presence	To offer physical and psychological support to the child and decrease anxiety

It can be summarized that addressing dental fear and anxiety in children has multiple immediate and long-term benefits. It enables the child to receive dental treatment in a safe and efficient manner. Allaying dental fear and anxiety enables the child to develop a positive outlook to dental care and grow into an adult who can tolerate dental treatment in an outpatient setting without pharmacologic adjuncts. It shapes an adult who does not avoid dental care. It decreases the burden of dental disease by improving oral health-related quality of life. The overall financial burden to the family and insurance system is decreased by decreasing dental fear and anxiety in the child.

There are several basic behavior guidance techniques that should be utilized to make the dental appointment a positive experience for the child (Table 1.4). When a child exhibits dental fear and anxiety which cannot be reduced by these techniques alone, such basic behavior guidance techniques can be augmented by utilization of inhalational nitrous oxide/oxygen. It is important to keep in mind that nitrous oxide inhalation leads to effective anxiolysis only in conjunction with these basic behavior guidance techniques such as tell-show-do and distraction (Figs. 1.16a, b and 1.17). Most of the times parental presence is also crucial along with basic behavior management techniques especially when parents are over protective or over indulgent (Fig. 1.18).

Basic behavior management techniques form the pedestal for using nitrous oxide sedation in children to reduce fear and anxiety.

Fig. 1.16 (**a** and **b**) Tell-show-do technique for a child

Fig. 1.17 Distraction of child to reduce anxiety

Fig. 1.18 Parental presence can be allowed during nitrous oxide sedation

1.2 Purpose of Nitrous Oxide in Children

Purpose of using nitrous oxide inhalation sedation should be clear to make it effective. It is an invaluable tool for behavior management (rather behavior guidance) in children [44, 45]. Since it brings about some sedation, it does not mean that it should be used only for children who are not cooperative for dental treatment. It has various purposes in children.

1.2.1 Reduce Fear and Anxiety

Nitrous oxide has euphoric and anxiolytic properties because of which it has a role in reducing fear and anxiety in children. Due to previous unpleasant experience of the child or parents, child may have developed fear of visiting a dentist. This initiates a vicious cycle as fear may lead to avoidance of treatment which further aggravates the caries status of the child. Use of nitrous oxide helps in breaking this vicious cycle, thereby preventing the child from having a poor oral health which in turn may affect his general health.

1.2.2 Enhance Communication of a Child with the Dentist

Many a times, a dentist is unable to address the anxiety of the child because of lack of communication from the child. This lack of communication may be due to the lack of trust ("unpleasant experiences" shared by parents or friends) or shy behavior of the child. With the use of nitrous oxide gas, child's anxiety gets reduced. The child sheds barrier formed around him and begins to interact with the dentist. The dentist may then be able to ascertain the reason for the lack of trust and fear in the mind of the child. This helps dentist in dealing with the child by addressing his/her concerns (Fig. 1.19).

Fig. 1.19 Using nitrous oxide on a fearful child enhances communication with the child

1.2.3 Instills a Positive Dental Attitude in Children for the Dentist and Dental Treatment

Even though a child may be cooperative for dental treatment, but he may not like visiting a dentist for complete treatment or preventive treatment. This is because of some sensitivity during treatment, tiredness of keeping mouth open, irritation with the sound of dental drills or suction, etc. Since nitrous oxide has euphoric and analgesic properties, children enjoy getting the treatment done and may look forward to subsequent visits. This instills a positive dental attitude in the child for the entire life.

> Main purpose of using nitrous oxide in pediatric dentistry is to not only reduce fear and anxiety in children and parents towards dentists and dental treatment but also build a positive dental attitude. This helps in building trust and confidence of children and parents.

1.2.4 Improves the Quality of Dental Treatment Rendered to Children

Many dentists struggle treating a child and would like to complete the work in the shortest possible time, thereby compromising on the quality of treatment rendered to a child. Since nitrous oxide is used to bring about minimal sedation, unwarranted tongue and lip movements are reduced. These factors contribute towards improving the quality of dental treatment.

1.2.5 Increases Efficiency of the Operator

A dentist is able to accomplish more work in a single appointment with nitrous oxide gas than without because less time is spent in managing the behavior of the

child. As there is lesser unwarranted movement of the child, the operator is able to practice quadrant dentistry, which in turn decreases the number of future visits.

1.2.6 Reduces Fatigue

With the use of nitrous oxide gas, less talking or verbal distraction is required, which reduces the fatigue of the operator. This, in turn, improves the overall efficiency of the dentist, as he/she is able to treat more number of patients on a particular day without getting tired.

1.2.7 Reduces Gag Reflex

Gagging is a normal reflex response in a healthy child. It may, however, interfere with various dental procedures such as taking X rays, making impressions, and restorative treatment. Sometimes, this response is so strong that it may lead to an avoidance of the dental treatment.

There are various causes of gagging such as systemic disorders, drug induced, physiologic, psychological, and iatrogenic [46]. In children, mostly the cause of gagging is psychological, that is fear [47].

Nitrous oxide oxygen sedation has use in reducing the gag reflex in a child. This is because gagging is related to specific fear, anxiety, which gets reduced by nitrous oxide due to its anxiolytic property [48]. Langa [49] states that although "nitrous oxide sedation does not totally eliminate gagging in extreme cases, it depresses the gag reflex sufficiently that a good impression is obtained at first attempt in all instances."

Malamed is also of the opinion that using nitrous oxide and oxygen sedation can help with reducing the hypersensitive gag reflex [50].

The mechanism by which nitrous oxide obtunds the gag reflex is not clear. It may be proposed that the anxiolytic (sedative) properties of nitrous oxide play a major role in the reduction of the gag reflex [51].

1.2.8 Reduce Stressful Environment

Pediatric dental practice can create a stressful environment due to crying children, clashes with interfering parents, and difficult access in small mouth of children. Nitrous oxide can help in creating a peaceful, stress-free, and relaxing environment in a pediatric dental practice.

> Using nitrous oxide is not only beneficial for the child but also for pediatric dentist and staff because it reduces stressful environment usually present in a pediatric dental practice.

1.2.9 Role of Basic Behavior Management Technique

The dentist should be able to judge the expected level of cooperation during the first dental visit and accordingly decide to use nitrous oxide inhalation sedation. Nitrous oxide sedation for child patients is ineffective in the absence of basic behavior management techniques.

Basic behavior management techniques are essential for building a rapport with the child so that the child is able to interact with the dentist. This is essential for introducing the nasal hood to the child effectively.

However, if basic behavior management techniques are used alone initially for children who are not willing for dental treatment, then making them use inhalation sedation mask later within the same setting, with the same dentist, becomes almost impossible because the child would have already developed some anxiety or fear for that setting and person.

Another common mistake or misconception is that children in precooperative age are considered for nitrous oxide inhalation sedation. The pediatric dentist should realize that if a child is not accepting basic behavior management technique, then making them accept nasal hood is not possible.

1.2.10 Purpose of Nitrous Oxide in Children with Different Behaviors

Nitrous oxide inhalation sedation has a purpose for children who are not only fearful but also the so-called cooperative for dental treatment.

Based on the FrAnkl's [52] behavior rating scale, the purpose of using nitrous oxide inhalation sedation for each of the category is mentioned below.

- **Definitely positive**—improves the efficiency of the operator, thereby reducing the time required to complete dental procedures. It also plays a major role in practicing quadrant dentistry for pediatric patients. It also helps in improving the quality of dental work provided to the child.
- **Positive**—instills a positive dental attitude and help in creating a "Happy child." Children will look forward towards their dental appointment. This, in turn, helps in instilling a positive attitude for dental treatment in parents. Parents will be more willing to accept the preventive treatment in children because they see that their children are comfortable during the dental procedures. They will also not focus only on the chief complaint rather will get all the teeth affected by dental caries treated.
- **Negative**—removes fear and anxiety of dentist/dental treatment. It thereby ensures an unpleasant procedure to be carried out in a child which would have otherwise caused distress in a child.
- **Definitely negative**—it reduces the number of cases being treated under general anesthesia. It also helps in treating an anxious or phobic child who would otherwise be denied access to dental treatment.

1.3 Indications of Using Nitrous Oxide in Pediatric Dentistry

1. ***Apprehensive and fearful children***

   Use of nitrous oxide is best indicated in children who are apprehensive, nervous, or uneasy about the upcoming dental treatment. Nitrous oxide will help in reducing this worrying feeling, thereby decreasing the hurdles posed by children during the treatment such as frequent movement, closure of the mouth, and asking for breaks.

   At the same time, if the level of fear is severe, then nitrous oxide may not be of great help during the dental treatment of such children. Anxiolysis brought about by nitrous oxide may not be sufficient enough to overcome fear in such children [53].
2. ***Examination of a child with a previous negative dental experience***

   A child who previously had a negative experience during a dental visit may not be willing to even sit on a dental chair. In such children, examination also becomes difficult and convincing them to accept dental treatment is nearly impossible. If the dentist is able to recognize the reason behind fear and introduces nitrous oxide even before attempting examination, then a proper examination becomes much easier (a proper examination involves use of compressed air to dry the tooth for visual inspection of a carious tooth and taking radiographs).
3. ***Examination for preschoolers***

   Examination of preschoolers is many a times challenging due to their cognitive ability or anxiety. If a dentist is able to encourage the use of nitrous oxide mask, then a thorough examination can be carried out under the influence of nitrous oxide.

> Intra-oral examination should be done using nitrous oxide in children who appear to be anxious in the first appearance. Attempting examination without nitrous oxide may further increase anxiety in such children.

4. ***Examination in special children***

   Children with special health care needs such as autism spectrum disorder, attention deficit hyperactive disease, and cerebral palsy have higher levels of anxiety due to the pre-existing medical or behavioral conditions. Use of nitrous oxide in such children, at the first instance before examination, will help in reducing their anxiety and building trust as well as confidence with the dentist [54, 55].
5. ***To reduce the perception of time and reduce fatigue***

   During the course of treatment, even a cooperative child may say that he/she is tired and doesn't want to get more treatment done. This can pose a problem in completing the planned treatment or practicing quadrant dentistry for a child [56].

   Using nitrous oxide alters the sense of time in children and thereby assists dentist in performing uninterrupted treatment for children.

6. ***To control gagging***
   Gag reflex is common in children, which poses difficulty while taking radiographs, making impressions, taking photographic records, or even examination with a mouth mirror in certain instances. Nitrous oxide reduces the gag reflex and thereby makes it possible for a clinician to perform these tasks effectively [48, 57, 58].
7. ***To perform a procedure for which profound anesthesia cannot be achieved***
   Many a times, extraction of an abscessed maxillary tooth, pulp therapy in a tooth with acutely inflamed pulp can pose a challenge because the local anesthesia administered using the infiltration technique may not be effective enough to perform the procedure without causing pain. In these scenarios, use of nitrous oxide can be of great benefit because of its analgesic properties.
8. ***Age***
   Although there is no minimum age requirement for the use of nitrous oxide, its success is dependent on the concurrent use of behavior management techniques. Some authors have recommended 4 years [54] as cutoff age, and others have suggested 6 [55] or 8 [59] years as minimum age for practice of nitrous oxide (The reason cited was that the behavior management skills were sufficient to manage most of the children and children below these ages needed other form of sedation [59]). It has been mentioned earlier in this book that nitrous oxide is used for behavior guidance and therefore, has some purpose in children of all age groups, provided they are able to accept the nasal hood.
9. ***Medical History***
   Nitrous oxide sedation is best suited for children falling under ASA category I and II. For children under ASA III, prior consultation and opinion from primary care physician or consulting medical specialist is necessary. **(ASA Classification is described in Appendix II.)**

1.4 Contraindications for the Use of Nitrous Oxide in Children

1.4.1 Systemic or Behavioral Causes

1. **Chronic obstructive pulmonary disease**
   Although COPD is usually seen in adults, in extremely rare cases, children may get COPD due to the genetic disorder alpha-1 antitrypsin deficiency [60]. Children will experience similar symptoms, including difficulty in breathing and shortness of breath. In this condition, there is a poor exchange of gases in the lungs leading to hypoxemia and hypercarbia. Poor exchange could be due to reversible bronchospasm and irreversible bronchial obstruction. This has two consequences.
   (a) As a result of poor exchange of gases into and out of the lungs, it is more difficult to administer nitrous oxide/oxygen gases to the child and also recover them back. This may compromise the safety factor of nitrous oxide/oxygen sedation.

(b) There is a hypoxemic drive (compensatory mechanism in which reduced oxygen in the blood due to poor alveolar exchange stimulates breathing) which helps in compensating for hypoxemia. However, with the use of nitrous oxide sedation which delivers high concentration oxygen, hypoxemic drive can be reduced. The patient can lose much or all of the respiratory drive. This potential for apnea, fortunately, is more theoretical and rarely becomes a clinical problem [61].

History of asthma is not a contraindication for the use of nitrous oxide since nitrous oxide is not irritating to the tracheo-bronchial tree. Nitrous oxide decreases emotional stress, thereby reducing the precipitating factor for asthma.

2. **Bowel obstruction or abdominal pain**

   Since nitrous oxide gas readily replaces nitrogen in air-filled cavities, hence when used in cases of bowel obstruction, it may cause abdominal pain due to distention of abdomen. When a child is having constipation, it may also cause abdominal pain during the nitrous oxide sedation. A meta-analysis found that nitrous oxide resulted in a time-dependent increase in bowel distention [62]. The amount of increase in pressure in bowel is also related to the partial pressure of nitrous oxide and the intestinal blood flow [63].

3. **Middle ear surgery/infections/otitis media**

   Nitrous oxide can increase intratympanic pressure during sedation and cause negative pressure after it is discontinued, mainly in patients with eustachian tube dysfunction. Increase in intratympanic pressure is related to the property (fast entry into air-filled cavities) of nitrous oxide gas. In children, eustachian tube pressure is slightly negative compared to an adult. Most children, even those who are not suffering from middle ear disease, have difficulty in maintaining appropriate pressure. Stiffness of eustachian tube is responsible for maintaining appropriate pressure which is relatively pliable in children. This leads to an increased incidence of middle ear disease in children. As soon as the nitrous oxide gas administration is stopped, it rapidly displaces out of the middle ear, creating a higher negative pressure which may promote insufflations, aspiration, or reflux of nasopharyngeal secretions into the middle ear. Thus, some children may report of ear pain after the procedure [64–66].

   There has been a report of multiple episodes of postoperative hearing loss in a child suffering from Crouzon's syndrome after she received nitrous oxide as a part of general anesthetic. Narrowing of the internal acoustic meatus in this syndrome may make these patients more susceptible to increased middle ear pressure secondary to inhalation of nitrous oxide, thus increasing their risk for hearing loss.

4. **Severe emotional disturbances/psychiatric disorders or drug-related dependencies**

   Many psychiatric patients are not able to handle the dental treatment due to higher anxiety. Such patients may be receiving psychotropic drugs which usually alter the cerebral cortex function. They may also be on medication bringing

about some sedation. Therefore, nitrous oxide sedation should be carefully administered in such children who may need close monitoring since their reaction may be unpredictable [55, 67, 68].

5. **Treatment with bleomycin sulfate**

   Bleomycin is an antineoplastic antibiotic used in the treatment of certain neoplasms such as Hodgkin's and non-Hodgkin's lymphoma. This is used as an adjunct to surgery and radiation therapy. Ten to twenty percent of patients receiving bleomycin therapy may develop interstitial pneumonitis which is considered as the most toxic effect of bleomycin. Although pulmonary toxicity most frequently occurs in older patients, it is unpredictable and may develop in younger patients and with low-dose therapy. Thus, there is an increased risk of developing pulmonary toxicity when oxygen is administered to patients who have received bleomycin [58, 69].

   It is reported that patients can develop respiratory failure when exposed to oxygen in a concentration greater than 25% [7]. Since during nitrous oxide sedation, oxygen concentrations vary from 100 to 30%, such patients will be at high risk of respiratory failure.

6. **Autoimmune disorders or children on immunosuppressive therapy**

   Nitrous oxide is believed to cause depression of bone marrow activity which can lead to a reduction in production of erythrocytes and leukocytes. Since bone marrow has a reserve of mature cells, a single exposure to nitrous oxide will not be of clinical significance because the bone marrow reserve will replenish the need of erythrocytes and leukocytes. This depression of marrow activity bounces back in 3–4 days. If nitrous oxide is administered repeatedly during this period, it may extend the inhibition of synthesis which may exceed the safety factor of stored cells. Therefore, the use of nitrous oxide gas, repeatedly at less frequent intervals, may cause further reduction in immune response of the body.

7. **Cobalamin deficiency**

   Vitamin B_{12} is a bound coenzyme of methionine synthase and has a tetrapyrrole ring with monovalent cobalt at the center. The cobalt functions as a methyl carrier in the transmethylation reaction. The sole biochemical effect of nitrous oxide is to block the transmethylation reaction as it converts monovalent cobalt to an inactive trivalent form. Methylation reactions have a role to play in DNA/RNA synthesis (turning on/off genes), brain chemical production (e.g., dopamine, serotonin, epinephrine), hormonal breakdown (e.g., estrogen), creation of immune cells (e.g., NK cells, T cells), creation of protective coating on nerves (i.e., myelin formation), and processing of chemicals and toxins (detoxification).

   Thus, nitrous oxide is contraindicated in cases of methionine synthase deficiency, methylene tetrahydrofolate reductase deficiency, or vitamin B_{12} deficiency which may further decrease the methionine levels required for protein synthesis and methylation reactions.

8. **Children who are in precooperative stage**

   The children do not have cognitive ability developed enough to understand the use of nasal hood. A child who is less than 30 months old usually will not

understand putting a mask on the nose. Even if they allow, they may not let it stay there for more than few minutes. If the mask is put forcefully on the child's nose by using restraint, then the child may get more anxious [53].

A clinical tip is that if the child has used nebulization mask and is comfortable using it at home, then the child may use the nitrous oxide nasal hood easily.

9. **Extremely anxious and fearful children who are crying uncontrollably**

   It is very difficult to explain the process of using nitrous oxide in such children and hence this technique may not be successful. A child who is usually unresponsive to audiovisual distraction will usually not inhale nitrous oxide efficiently. Sometimes, resorting to basic behavior management techniques, over a period of 1–3 visits, may make them develop rapport with the dentist, thereby making it possible to use nitrous oxide nasal hood [70].

A clinical tip is that if a child is not willing to enter the dentist office or is extremely fearful of external factors, such as a hair cut, then the child may not be a good patient for using this technique.

10. **Children who are unable to communicate**

    Children who are otherwise cooperative but unable to communicate because of systemic disorders or mental delays may not respond well to verbal commands during nitrous oxide sedation. This may make it difficult for the operator to seek purposeful response to verbal commands thereby misjudging the level of sedation [56, 71].

    Also, children who speak and comprehend language other than that used by the clinician, may face challenges in understanding.

11. **Child wants to get treatment done using nitrous oxide**

    Once exposed to nitrous oxide, a child may demand its use, even though no treatment is required. This is because of the euphoric potential of nitrous oxide. In such situations, dentist should counsel the child against its unnecessary use.

12. **Children with behavioral issues**

    Hysterical, stubborn, or defiant patients may be difficult candidates for introducing nitrous oxide mask.

13. **Child suffering from multiple sclerosis**

    Frequent exposure to nitrous oxide for performing dental treatment in a child suffering from multiple sclerosis is not recommended as it may cause neuropathies. Patients with multiple sclerosis suffer from nerve demyelination, and the symptoms may worsen by nitrous oxide-induced neuropathy [72].

1.4.2 Local Causes

1. **Surgery involving the anterior surface of maxilla**
   Nitrous oxide sedation requires a nasal hood to rest on the upper lip throughout the dental procedure. If any surgery has to be carried out in the anterior surface of maxilla such as extraction of an impacted tooth, removal of odontomes, and cysts, it becomes difficult to retract the upper lip for surgical access. Hence, nitrous oxide nasal hood poses a challenge for surgical procedures involving the anterior surface of maxilla [73] (Fig. 1.20).
2. **Mouth breather**
   A child, who is a mouth breather because of obstructive causes such as nasal polyps, deviated nasal septum, or enlarged adenoids may find it difficult or impossible to breathe through the nose. It may be futile to use nitrous oxide sedation through the nasal hood in such patients as they won't be able to breathe through the nose, thereby making nitrous oxide sedation ineffective [74, 75].
3. **Difficulty in breathing through nose or upper airway infection**
   A child who is otherwise able to breathe normally through nose but is unable to do so on a particular day because of nasal congestion or upper airway infection may find it difficult to breathe through nose, thereby causing nitrous oxide sedation ineffective [73].

Nitrous oxide has no absolute contraindications and is a useful alternative to general anesthesia [76]. Table 1.5 enlists various conditions in which use of nitrous oxide may or may not be contraindicated.

Fig. 1.20 Difficulty in administering local anesthesia in the maxillary anterior region due to the nasal hood

Table 1.5 Categorization of contraindications

No contraindications	Possible contraindications	Absolute contraindications
Cardiovascular system Heart murmur, congenital conditions, rheumatic fever, transplant	Sinus infection/congestion—may need postponement of appointment	Recent eye surgery
Central nervous system Seizure disorders	Tuberculosis or upper respiratory infection	Recent ear surgery
Respiratory system Asthma—N_2O is not contraindicated as it reduces the stress-provoking stimuli which usually precipitate asthma	Ear infection—may require postponement of appointment	Latex allergy
Hematological disorders Anemias, methemoglobinemia, sickle cell anemia, leukemia, hemophilia, polycythemia vera	Mental illness, autism, psychiatric disorders	Bleomycin therapy
Hepatic diseases Hepatitis, jaundice	Stomach pain May require postponement	
Endocrine system Thyroid/adrenal dysfunction, diabetes	Claustrophobia	
Kidney diseases No effects of nitrous oxide		
Neuromuscular system Multiple sclerosis, muscular dystrophy, cerebral palsy, myasthenia gravis		
Cancer N_2O creates a sense of well-being and relaxation		

Source: Paarmann C, Royer R. Pain control for dental practitioners: An interactive approach [77]

1.5 Advantages of Using Nitrous Oxide in Children

Nitrous oxide inhalation sedation has various advantages to other sedative techniques used in children such as oral, intramuscular, intranasal, or intravenous.

1.5.1 Fast Onset

The onset of subjective symptoms using nitrous oxide sedation is much faster compared to other sedative techniques especially oral technique. There is always a lag period after administration of oral sedative because of the time required for the drug to be absorbed by the stomach mucosa [33].

Fast onset of nitrous oxide gas is attributed to its low blood gas partition coefficient (Refer Chap. 2).

1.5.2 Ease of Administration

If a child is willingly accepting a nasal hood, then the ease of administration of nitrous oxide sedation is much higher compared to other techniques. During oral administration of a sedative drug, the child may not completely ingest the drug. He/

she may spit out a part of the drug mixed with saliva making it difficult for the operator to determine the exact dose of sedative administered to the child. Intranasal administration is also not easy as putting the drug in the nose causes a lot of irritation to the child. Again, the exact desired amount of drug may not be delivered to the child. Intravenous/intramuscular is definitely not convenient for a child as it employs the use of a needle.

1.5.3 Sedation Level Can Be Adjusted Based on Response (Titratable)

This property is of great benefit in a non-hospital setting as the sedation level could be reduced by reducing the concentration of the drug delivered to the child. This is also related to its property of fast onset and fast recovery, as for other techniques, the sedation level cannot be adjusted once the drug is administered through other routes because the entire amount of drug is delivered inside the body in one go. Thus, after the administration of the drug, sedation response cannot be reduced.

On the other hand, more drug cannot be administered to the child if the sedation response is less than desired because the sedative drug is administered based on the body weight of a child. If more drug is administered, then the additive effect might lead to a deeper level of sedation.

1.5.4 Quick Recovery

Similar to fast onset, nitrous oxide gas has a quick recovery period, making it safer compared to other sedative agents and also prevents the need for any postoperative recovery period [67].

1.5.5 Ability to Communicate During Procedures

Since nitrous oxide sedation causes only minimal to moderate level of sedation, the child will be able to communicate during the procedure making it safer compared to other sedative agents (Fig. 1.21). This has a psychological impact on the parents because they feel that the child is well in control of the situation and has not gone into a state where they cannot carry out a meaningful dialogue with the child.

1.5.6 Safe Compared to Other Agents

Safety index of nitrous oxide sedation is much higher compared to other sedative agents. Nitrous oxide sedation is believed to have a safety record of more than 100 years.

Fig. 1.21 Operator can communicate with the child during the procedure

1.5.7 No Impact on Daily Duties

A child can go to school, play outdoors or indoors, study or carry out any other activity soon after the dental procedure under nitrous oxide sedation. This has a major impact on the minds of the parents because it is then considered equivalent to a normal dental procedure. It does not affect their schedule also as they are not required to stay back with the child leaving their work. However, with other sedative techniques, this is not achievable because it requires varying periods of postoperative monitoring in the clinic depending on the sedation. This definitely has to be followed with the need of parents accompanying their child at home for a few hours after the procedure.

Main advantage of nitrous oxide sedation is related to its property of fast onset and fast recovery.

Other modes of sedation have clear disadvantages over nitrous oxide sedation (inhalation sedation) which have been summarized in Table 1.6.

1.6 Disadvantages of Nitrous Oxide in Children

Nitrous oxide inhalation sedation has certain disadvantages associated with it such as follows:

1. ***Poor acceptance of the nasal mask***

   Children who are extremely anxious may not accept the nasal mask readily (Fig. 1.22). Acceptance of nasal mask is of utmost importance for nitrous oxide inhalation sedation. Also during the procedure, child may not keep the mask

Table 1.6 Disadvantages of other modes of sedation over inhalational mode (nitrous oxide)

Route of administration	Disadvantages over nitrous oxide sedation
Oral	• Cannot titrate the drug • Delay in onset • Varying response due to difference in gastric absorption • No oral reversal drug present • Longer pre-procedural fasting required
Intramuscular	• Difficult for patients who are needle phobic • Can cause muscular pain • Over sedation possible • Longer pre-procedural fasting required
Intravenous	• Difficult for patients who are needle phobic • Over sedation possible • Longer pre-procedural fasting required
Intranasal	• Difficult to administer • Can cause burning sensation in nasal mucosa • Over sedation possible

Fig. 1.22 Poor acceptance of nasal mask in extremely anxious children

untouched and undisturbed. He/she may move the mask or move his/her face disturbing the position of the mask which reduces the efficacy of nitrous oxide sedation. This disadvantage can be overcome by the use of basic behavior management techniques.

2. ***Relative weak potency of nitrous oxide/oxygen***

   Nitrous oxide gas also has biovariability associated with it. Hence, in few of the children, the effect of nitrous oxide sedation is not clinically evident. Even at a higher concentration of nitrous oxide, the child may not have reduced anxiety or may not have clinically desired level of sedation. In many instances, using basic behavior management techniques usually helps in overcoming this disadvantage.

3. ***Difficulty in introducing nasal mask in children of precooperative age***

   Children who are less than 3 years old usually do not have cognitive ability developed enough to understand the use of a nasal mask (Fig. 1.23). Hence, they may not allow the mask to be used because of which, nitrous oxide sedation has a smaller role in children who are less than 3 years old [53].

There may be a few children less than 3 years old who may willingly accept the mask and hence can be considered for nitrous oxide sedation.

Fig. 1.23 Difficulty in introducing nasal mask in children in precooperative age

4. ***Associated with nausea or vomiting***
   Few children develop nausea or vomiting on using nitrous oxide sedation. This is seen more in children who have motion sickness or have taken fatty food before the appointment.
5. ***No role in post-treatment pain***
   Children who are very comfortable during the treatment because of analgesic properties suddenly start crying at the end of the procedure because of loss of analgesic properties which are diminished as the nitrous oxide concentration is reduced to zero. This is usually seen after placement of stainless steel crowns without local anesthesia. A heightened response is also seen with local anesthesia. During the course of nitrous oxide sedation, the child will not realize numbness associated with local anesthesia, but as soon as nitrous oxide is reduced child realizes numbness and may start showing unhappiness over numb feeling.
6. ***Children with behavioral problems***
   Children who suffer from anxiety disorders, may start shouting or crying suddenly during the course of nitrous oxide sedation because they are not able to understand the subjective symptoms such as tingling in extremities or light headedness. This disadvantage can be overcome by explaining the expected feelings before starting the use of nitrous oxide.
7. ***Dependence on psychological assurance***
   Nitrous oxide efficacy is largely dependent on psychological assurance. The child has to be told about expected feelings and reassured that such feelings are expected. Many a times, such feelings should be associated with euphemisms.
8. ***Occupational hazard for the dental personnel***
   Chronic exposure of nitrous oxide gas to the dental personnel in an unscavanged operatory poses some health risk to the dentists and their staff [69].
9. ***Cost of equipment***
   Nitrous oxide sedation usually requires the use of specialized equipment like flowmeters. Also there is a recurring need for nitrous oxide and oxygen cylinders which have to be procured from a medical gas supplier on a regular basis. This may be difficult at times considering the weight of the cylinders, making it challenging to transport the cylinders [73, 78].
10. ***Not an alternative to local anesthesia***
    Although nitrous oxide has analgesic properties, it cannot substitute local anesthesia completely. It only serves as an adjunct to local anesthesia [79].

Hence, the advantages of using nitrous oxide sedation in children usually outweigh its disadvantages.

1.7 Conclusion

At the end of this chapter, we realize that recognizing as well as dealing with fear and anxiety is crucial for effectively introducing the technique of nitrous oxide sedation in children. In 2003, the American Academy of Pediatric Dentistry introduced the term **"behavior guidance"** in lieu of "behavior management." This was

done to emphasize that the goal is not to "deal" with a child's behavior but to "enhance communication with the parent and child to promote a positive attitude and good oral health." In conjunction with **behavior guidance** techniques, nitrous oxide, due to its anxiolytic and analgesic properties, can promote "positive experiences," thereby helping the child to not only maintain a good dental health at a young age, but also help him/her develop a positive dental attitude, which, in turn, may help in improving the dental health of the community as a whole. Nitrous oxide sedation is safer and reliable compared to other forms of sedation and can help in reducing the number of children being treated under general anesthesia for dental rehabilitation.

References

1. Miller-Keane, O'Toole MT. Miller-Keane encyclopedia & dictionary of medicine, nursing & allied health, 7th edn. Elsevier; 2003.
2. Chapman HR, Kirby-Turner NC. Dental fear in children—a proposed model. Br Dent J. 1999;187(8):408–12.
3. Adolphs R. The biology of fear. Curr Biol. 2013;23(2):R79–93.
4. Ollendick T, King N, Muris P. Fears and phobias in children: phenomenology, epidemiology and aetiology. Child Adolesc Mental Health. 2002;7(3):98–106.
5. Freud S. Analysis of a phobia in a five year old boy. In: Collected papers. London: Hogarth Press and the Institute of Psycho-Analysis; 1925. p. 3.
6. Josselyn IM. Concepts related to child development: the oral state. J Am Acad Child Psychiatry. 1962;1(2):209–24.
7. Matthews SN. Children's fears: developmental or disorder. 2010. https://www.sbbh.pitt.edu/Booklets%202113%20fall%202010/Fears_Matthews.pdf.
8. Derevensky JL. Children's fears: a developmental comparison of normal and exceptional children. J Genet Psychol. 1979;135:11–21.
9. LeDoux JE, Pine DS. Using neuroscience to help understand fear and anxiety: a two-system framework. Am J Psychiatry. 2016;173(11):1083–93.
10. Holst A. Behaviour management problems in child dentistry. Frequency, therapy and prediction. Swed Dent J Suppl. 1988;54:1–55.
11. Maren S. Neurobiology of Pavlovian fear conditioning. Annu Rev Neurosci. 2001;24:897–931.
12. Maren S, Holmes A. Stress and fear extinction. Neuropsychopharmacology. 2016;41(1):58–79.
13. Gao X, Hamzah SH, Yiu CK, McGrath C, King NM. Dental fear and anxiety in children and adolescents: qualitative study using YouTube. J Med Internet Res. 2013;15(2):e29.
14. Lee CY, Chang YY, Huang ST. The clinically related predictors of dental fear in Taiwanese children. Int J Paediatr Dent. 2008;18(6):415–22.
15. Jaakkola S, Rautava P, Alanen P, Aromaa M, Pienihakkinen K, Raiha H, et al. Dental fear: one single clinical question for measurement. Open Dent J. 2009;3:161–6.
16. Milgrom P, Weinstein P, Kleinknecht R, Getz T. Treating fearful dental patients. Reston, VA: Reston Publishing Co; 1985.
17. Öst LG, Skaret E. Cognitive behavioral therapy for dental phobia and anxiety. West Sussex: Wiley-Blackwell; 2013.. ISBN: 978-1-118-49951-1.
18. Shim YS, Kim AH, Jeon EY, An SY. Dental fear & anxiety and dental pain in children and adolescents; a systemic review. J Dent Anesth Pain Med. 2015;15(2):53–61.
19. Economou GC. Dental anxiety and personality: investigating the relationship between dental anxiety and self-consciousness. J Dent Educ. 2003;67(9):970–80.
20. The Anxious child. The Mental Health Foundation; 1997. https://www.mentalhealth.org.uk/sites/default/files/anxious_child.pdf. Accessed 6 Feb 2019.
21. Thomas A, Chess S, Birch HG. The origin of personality. Sci Am. 1970:102–9.

22. Rothbart MK, Ahadi SA, Evans DE. Temperament and personality: origins and outcomes. J Pers Soc Psychol. 2000;78:122–35.
23. Piacentini J, Roblek T. Recognizing and treating childhood anxiety disorders. West J Med. 2002;176(3):149–51.
24. Armfield JM, Heaton LJ. Management of fear and anxiety in the dental clinic: a review. Aust Dent J. 2013;58(4):407; quiz 531.
25. Beaton L, Freeman R, Humphris G. Why are people afraid of the dentist? Observations and explanations. Med Princ Pract. 2014;23(4):295–301.
26. Cianetti S, Lombardo G, Lupatelli E, Pagano S, Abraha I, Montedori A, et al. Dental fear/anxiety among children and adolescents. A systematic review. Eur J Paediatr Dent. 2017;18(2):121–30.
27. Hargreaves K, Berman L. Cohen's pathways of the pulp. 11th ed. St. Louis: Mosby; 2015.
28. Milgrom P, Mancl L, King B, Weinstein P. Origins of childhood dental fear. Behav Res Ther. 1995;33(3):313–9.
29. Moore R, Brodsgaard I, Birn H. Manifestations, acquisitions and diagnostic categories of dental fear in a self-referred population. Behav Res Ther. 1991;29(1):51–60.
30. Gustafsson A. Dental behaviour management problems among children and adolescents—a matter of understanding? Studies on dental fear, personal characteristics and psychosocial concomitants. Swed Dent J Suppl. 2010;202(2):1–46.
31. Tsao JC, Lu Q, Kim SC, Zeltzer LK. Relationships among anxious symptomatology, anxiety sensitivity and laboratory pain responsivity in children. Cogn Behav Ther. 2006;35(4):207–15.
32. Gustafsson A, Arnrup K, Broberg AG, Bodin L, Berggren U. Psychosocial concomitants to dental fear and behaviour management problems. Int J Paediatr Dent. 2007;17(6):449–59.
33. Bankole OO, Aderinokun GA, Denloye OO, Jeboda SO. Maternal and child's anxiety-effect on child's behaviour at dental appointments and treatments. Afr J Med Med Sci. 2002;31(4):349–52.
34. Hakeberg M, Berggren U, Gröndahl HG. A radiographic study of dental health in adult patients with dental anxiety. Community Dent Oral Epidemiol. 1993;21(1):27–30.
35. Rantavuori K, Lahti S, Hausen H, Seppa L, Karkkainen S. Dental fear and oral health and family characteristics of Finnish children. Acta Odontol Scand. 2004;62(4):207–13.
36. Taani DQ, El-Qaderi SS, Abu Alhaija ES. Dental anxiety in children and its relationship to dental caries and gingival condition. Int J Dent Hyg. 2005;3(2):83–7.
37. Nicolas E, Collado V, Faulks D, Bullier B, Hennequin M. A national cross-sectional survey of dental anxiety in the French adult population. BMC Oral Health. 2007;7:12.
38. Versloot J, Veerkamp JS, Hoogstraten J. Children's self-reported pain at the dentist. Pain. 2008;137(2):389–94.
39. Townend E, Dimigen G, Fung D. A clinical study of child dental anxiety. Behav Res Ther. 2000;38(1):31–46.
40. Hallberg U, Camling E, Zickert I, Robertson A, Berggren U. Dental appointment no-shows: why do some parents fail to take their children to the dentist? Int J Paediatr Dent. 2008;18(1):27–34.
41. Poulton R, Thomson WM, Davies S, Kruger E, Brown RH, Silva P. Good teeth, bad teeth and fear of the dentist. Behav Res Ther. 1997;35(4):327–34.
42. Krekmanova L, Bergius M, Robertson A, Sabel N, Hafström C, Klingberg G, Berggren U. Everyday- and dental-pain experiences in healthy Swedish 8-19 year olds: an epidemiological study. Int J Paediatr Dent. 2009;19(6):438–47.
43. Behavior guidance for the pediatric dental patient. Reference Manual V 40; 6 2018-19 American Academy of Pediatric Dentistry. http://www.aapd.org/media/Policies_Guidelines/BP_BehavGuide.pdf. Accessed 8 Feb 2019.
44. Emmanouil D, Kupietzky A. Nitrous oxide/oxygen inhalation sedation in children. Behavior management in dentistry for children. 2nd ed. Philadelphia: W.B. Saunders Co.; 2014. p. 145–58.
45. Musselman RJ, McClure DB. Pharmacotherapeutic approaches to behavior management. In: Wright GZ, editor. Behavior management in dentistry for children. Philadelphia: W.B. Saunders Co.; 1975. p. 146–77.

46. Kaufman E, Weinstein P, Sommers EE, Soltero DJ. An experimental study of the control of the gag reflex with nitrous oxide. Anesth Prog. 1988;35(4):155–7.
47. Kramer RB, Braham RL. The management of the chronic and hysterical gagger. J Dent Child. 1977;94:111–4.
48. Schroeder HE, Schroeder U, Santibánez-H G. Dentist phobia. Pavlov J Biol Sci. 1986;21(1):16–24.
49. Langa H. Relative analgesia in dental practice—inhalation analgesia and sedation with nitrous oxide. Philadelphia: Saunders; 1976.
50. Malamed S. Sedation: a guide to patient management. 5th ed. St. Louis, MO: Mosby; 2010.
51. De Veaux CKE, Montagnese TA, Heima M, Aminoshariae A, Mickel A. The effect of various concentrations of nitrous oxide and oxygen on the hypersensitive gag reflex. Anesth Prog. 2016;63(4):181–4.
52. Frankl SN, et al. Should the parent remain in the operatory? J Dent Child. 1962;29:150–63.
53. Loeppky WP, Milnes AR. When is it appropriate to use nitrous oxide and oxygen inhalation for children? JCDA. 2007;73(6):495–495a.
54. Hosey MT. Managing anxious children: the use of conscious sedation in paediatric dentistry. Int J Paediatr Dent. 2002;12(5):359–72.
55. American Academy of Pediatric Dentistry: policy on minimizing occupational health hazards associated with nitrous oxide. 2012–2013.
56. Levering NJ, Welie JVM. Current status of nitrous oxide as a behavior management practice routine in pediatric dentistry. J Dent Child (Chic). 2011;78(1):24–30.
57. Chidiac JJ, Chamseddine L, Bellos G. Gagging prevention using nitrous oxide or table salt: a comparative pilot study. Int J Prosthodont. 2001;14(4):364–6.
58. Hallonsten AL, Jensen B, Raadal M, Veerkamp J, Hosey MT, Poulsen S. Guidelines on sedation in pediatric dentistry. 2003. www.eapd.gr/dat/5CF03741/file.pdf.
59. Eid H. Conscious sedation in the 21st century. J Clin Pediatr Dent. 2002;26(2):179–80.
60. Does COPD affect children differently than adults? COPD. Health Topics/Lung Disease and Respiratory System/COPD Sharecare.com.
61. Malamed SF. In: Warfel DA, editor. Sedation: a guide to patient management. St. Louis: Mosby; 1985. p. 592.
62. Orhan-Sungur M, Apfel C, Akça O. Effects of nitrous oxide on intraoperative bowel distension. Curr Opin Anaesthesiol. 2005;18(6):620–4.
63. Akca O, Lenhardt R, Fleischmann E, et al. Nitrous oxide increases the incidence of bowel distension in patients undergoing elective colon resection. Acta Anaesthesiol Scand. 2004;48(7):894–8.
64. Fleser R. Nitrous oxide. From Discovery to Now.ineedCE.com. p. 1–7.
65. Carreiro J. An osteopathic approach to children. 2nd ed. Edinburgh: Churchill Livingstone; 2009. p. 310.
66. Krouse JH, Derebery MJ, Chadwick S. Managing the allergic patient. 1st ed. Philadelphia: Saunders; 2007.
67. Clark M. Back to the future: an update on nitrous oxide/oxygen sedation. 2009:1–9.
68. Clark MS, Brunick AB. Handbook of nitrous oxide and oxygen sedation. 3rd ed. St. Louis: Mosby; 2008.
69. Fleming P, Walker PO, Priest JR. Bleomycin therapy: a contraindication to the use of nitrous oxide-oxygen psychosedation in the dental office. Pediatr Dent. 1988;10(4):345–6.
70. Barbosa ACBM, Mourao J, Milagre V, de Andrade DC, Areias C. Inhalation conscious sedation with nitrous oxide/oxygen in pediatric dentistry. Med Express. 2014;1(3):102–4.
71. Allen SC, Bernat JE, Perinpanayagam MK. Survey of sedation techniques used among pediatric dentists in New York State. N Y State Dent J. 2006;72(5):53–5.
72. Nitrous oxide conscious sedation. http://icourses.uthscsa.edu/courses/nitrous/indications.html.
73. Berge TI. Nitrous oxide in dental surgery. Best Pract Res Clin Anaesthesiol. 2001;15(3):477–89.
74. Becker DE, Rosenberg M. Nitrous oxide and the inhalation anesthetics. Anesth Prog. 2008;55(4):124–31.

75. Wald C. Nitrous oxide—are there any real contraindications? Quintessence Int. 1983;7(2):213–8.
76. Patel S. Is nitrous oxide a safe agent to use in conscious sedation for dentistry? SAAD Digest. 2010;26:23–6.
77. Paarmann C, Royer R. Pain control for dental practitioners: an interactive approach, 1st edn. Wolters Kluwer; 2008.
78. McKinnon KD. Prehospital analgesia with nitrous oxide/oxygen. Can Med Assoc J. 1981;125(8):836–40.
79. Ulrich K. N_2O/O_2 sedation in pediatric dentistry. Pocket Dent. 2015:426.