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Use, attitudes, side effects and satisfaction with nitrous oxide sedation for dental treatment in Germany

Introduction: The use of nitrous oxide for minimal sedation in dentistry is only recently advocated by European and German associations, but its use in dental practice routine is hardly examined. Thus, the aim of this study is to evaluate the circumstances of nitrous oxide sedation in German dental practices.

Materials and methods: A questionnaire on the knowledge and attitudes of general dentists towards nitrous oxide sedation was sent to a representative sample of 100 dentists from the lists of the dental associations. A second questionnaire for 210 dentists who had purchased the according equipment covered domains of the user profile, indications, equipment and techniques and the procedure of their last nitrous oxide sedation.

Results: In general, German dentists exhibit a neutral (57 %) or positive attitude (29 %) towards minimal sedation with nitrous oxide (response rate 14 %). Due to the recent purchase of the devices, the years of experience of users were mostly low (only 16 % > 3 years, response rate 30 %) with varying levels of formal training. Still, the equipment, techniques and outcomes were in line with established recommendations. Mainly adults (62 %) with anxiety (87 %) were treated with surgical procedures (59 %) with a very high success rate and few minor side effects such as euphoria (5 %), sweating, nausea or vomiting (3 % each).

Conclusion: The responding dentists and patients were highly satisfied and saw nitrous oxide as an easy and predictable way to achieve minimal sedation during dental treatment, sometimes preventing a referral to general anesthesia. Thus, there is a potential that nitrous oxide could be as widely used in Germany as it is in other countries.

Keywords: dentistry; nitrous oxide; paediatric dentistry; sedation

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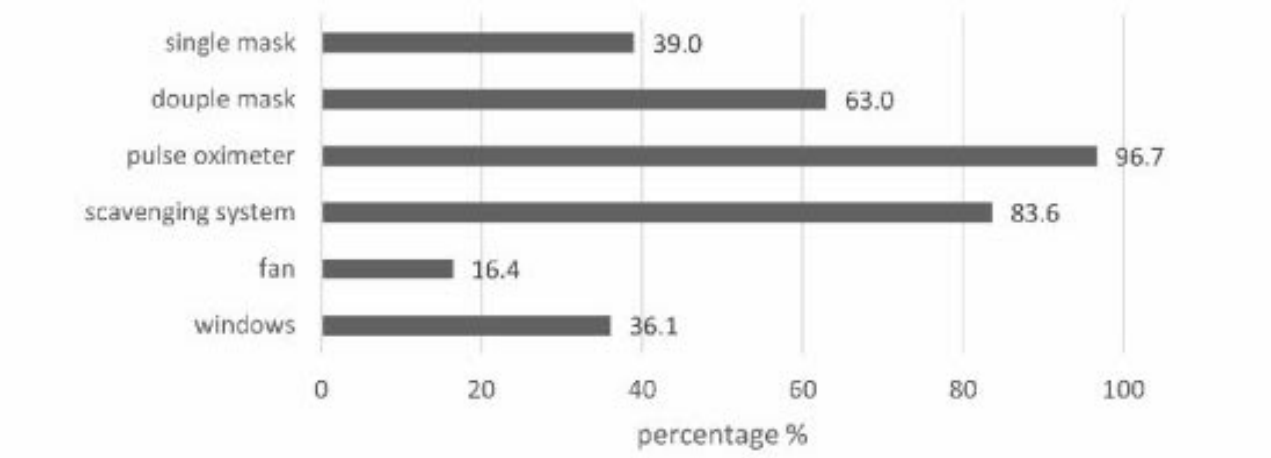


Figure 1 Use of equipment for application, monitoring and ventilation during sedation with nitrous oxide in German dental practices (multiple answers were possible)

1. Introduction

Nitrous oxide sedation is an old and established technique for the reduction of stress and anxiety during dental treatment [1]. According to the Council of European Dentists [20], the European Academy of Paediatric Dentistry [11] and a consensus paper by German anesthesiologists and German dentists [21], the use of nitrous oxide has recently been encouraged for minimal sedation in dental treatment.

However, there are only a few studies from continental Europe about how nitrous oxide is applied in dentistry [9, 12]. A study conducted in France with nitrous oxide as 50:50 premix with oxygen evaluated the treatment in 549 patients with intellectual disability, pre-cooperative children, adults or children with dental phobia and patients requiring a single complex dental treatment [12]. The dental procedures such as extractions, fillings, endodontics, surgery, scaling and impression were performed with a very high success rate (93.7 %) under nitrous oxide sedation. In 12.6 % of the sample, mild side effects were registered; mostly euphoria (3.5 %), nausea or vomiting (2.8 %). However, the French study used a system where no titration was possible due to the 50:50 premix, which could be a reason for higher complication rates.

Other studies showed that conscious sedation with nitrous oxide improved the cooperation during dental care for patients with behavioral difficulties such as very young children, patients with dental anxiety or phobia, and persons with intellectual disability [3, 9].

In Germany, as in many other countries, there is no comparable, published data about the use of sedation with nitrous oxide in dental practice or the views of the dentists about this technique. Studies on this topic can lead to a better implementation of nitrous oxide sedation and improve the training of current and future dentists. Thus, the aim of this study is to evaluate the following questions in a representative sample of German general dentists and dentists who had purchased nitrous oxide equipment:

- How high is the number of anxious patients in dental practices in Germany who could benefit from minimal sedation with nitrous oxide?
- How high is the number of general dental practitioners who are willing to use nitrous oxide in their practices?
- What are the reasons for not using nitrous oxide?
- What are the indications for nitrous oxide in dental treatment according to German dentists?
- What side effects of nitrous oxide did the users encounter and how often?
- How high is the failure rate of nitrous oxide in terms of both dental treatment and sedation?
- How is the satisfaction level of German dentists with nitrous oxide devices?
- How many dentists have the suitable equipment and have suitable space for applying nitrous oxide?
- In how many patients could the higher risk and cost of dental treatment under general anesthesia possibly be avoided with the help of nitrous oxide?
- What safety standards are applied when using nitrous oxide in the dental offices in Germany?

2. Materials and Methods

After approval by the Ethics Committee at the University of Greifswald, a first questionnaire was sent to 210 dentists who had purchased a nitrous oxide machine from the 3 main distributors in Germany (70 dentists each). The questionnaire covered domains of the user profile (time since graduation, years of experience with nitrous oxide), their attitudes towards nitrous oxide sedation, indications and referral patterns, frequency of application, equipment (type of sedation machine, use of pulse oximeter, ventilation system, type of masks), formal training (duration) and the techniques employed (titration, maximum concentration). In addition, for the procedure of the last treatment performed under sedation with nitrous oxide, patient characteristics (age, indication, dental procedure, duration), success rates (sedation, dental procedure), satisfaction

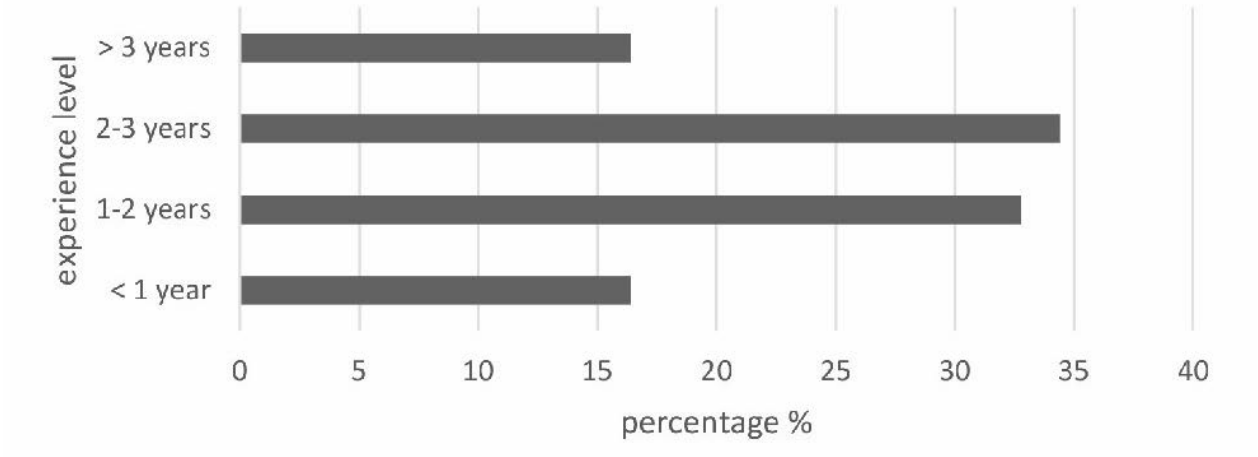


Figure 2 Years of experience in the use of nitrous oxide sedation in German dentists

by dentist and patient, next treatment options as well as complications and side effects were analysed. Data were recorded anonymously.

A second questionnaire on the knowledge and the attitudes of general dentists towards nitrous oxide sedation for dental treatment was sent to a representative sample of 100 dentists whose addresses were collected from the public internet pages of the 17 regional dental associations according to the relative size of the region. These data were also collected anonymously and contained information on their source of information on nitrous oxide sedation, their view on possible indications and a referral as well as past and future use of nitrous oxide sedation.

The descriptive analysis of data included ranges, frequency distributions and mean values. Analytical statistics are aiming at the different profiles of users and use of sedation with nitrous oxide, differences in use by general dentists, oral surgeons and pediatric dentists. Also patterns for side effects and complications during sedation were analyzed.

3. Results

3.1 Use of nitrous oxide in Germany

Sixty-one dentists who had purchased a nitrous oxide device returned the questionnaire (response rate 30.5 %). The systems for treatment with nitrous oxide that the 3 companies provided were "Acutron" (41 %), "Tecno-Gaz" (39 %), "Matrix" (13 %) and "Porter" (7 %).

The vast majority (83.6 %, Fig. 1) of the dentists had an extra suction system to evacuate the nitrous oxide, whereas 36.1 % of the dentists just open the window to reduce nitrous oxide concentrations. Few dentists used a fan (16.4 %) and 4.9 % employed other methods for ventilation (multiple answers were possible).

The use of a pulse oximeter in order to monitor heart frequency and oxygen saturation levels in the blood was an established standard (96.7 %). About two thirds used double masks for application (63.9 %) and 39.3 % used simple masks.

There was an unanimous consent that the prime indication for nitrous oxide sedation are patients with anxiety or phobia (95 %), while 49 % of the users also saw an indication for patients with complex treatment. Fewer dentists would use it for uncooperative children under 5 years of age or with mentally handicapped patients (20 % and 18 %, resp.). While half of the dentists applied nitrous oxide on patients without a relevant systemic disease only (46 %), the other half, used it on patients with medical conditions that were compensated or well controlled (53 %). Only one dentist used it also on patients with complex medical conditions.

Very few dentists applied nitrous oxide for dental treatment more than once per day 3.3 %, while most of them used it once per week (42.6 %) or once per month (41.0 %). 13.1 % reported a daily use.

The vast majority of dentists using nitrous oxide equipment (68 %) were completely satisfied with their devices. Twenty-eight percent of users were satisfied and only few dentists (3 %) were neither satisfied nor unsatisfied. No dentist that had purchased a nitrous oxide machine was unsatisfied or completely unsatisfied.

3.2 Experience levels and training

Fifty-four percent of the dentists had graduated from 1991 to 2000 and about equal numbers graduated before 1990 and from 2001 to 2010 (21 % and 23 %, resp.). Only one dentist had experienced training in nitrous oxide sedation during his undergraduate curriculum (1.6 %). The majority of the dentists who used nitrous oxide in their offices had taken part in training courses for 2 days (67 %), 15 % for less than 2 days and 18 % for more than 2 days.

Regarding the dentists' experience with nitrous oxide almost all dentists were using nitrous oxide sedation for less than 3 years (Fig. 2).

3.3 Report on patient treatment

The vast majority of patients treated with nitrous oxide during the last appointment were adults (62.2 %, Fig. 3), less than 20 % were children below the age of 10 years.

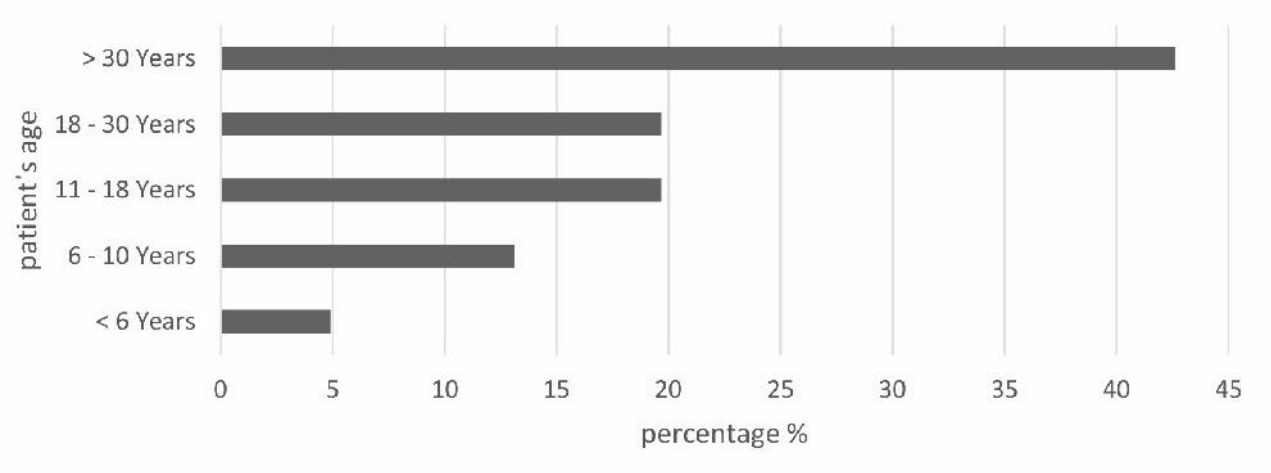


Figure 3 Age categories for patients treated with nitrous oxide sedation in German practices

The patients were mostly characterized by fear or phobia (87 %), a few were uncooperative children under the age of 5 years (7 %), mentally handicapped (5 %) or in need of complicated treatment (8 %).

The dental treatment performed under minimal sedation with nitrous oxide reflected the whole spectrum of dentistry with a clear focus on extractions (32.9 %) and fillings (30.4 %, Fig. 4).

The maximum concentration of nitrous oxide applied for the last patient was mostly 30–40 % (48 %) followed by 40–50 % (33 %). A minority had used a low concentration of 20–30 % (20 %).

The treatment time was mostly 30 to 60 min (44 %) or even shorter (30 %: 15–30 min, 7 %: less than 15 min). Few procedures lasted more than 60 min (20 %).

Titration time was mostly rather short with 69 % of the users reaching the maximum concentrations of nitrous oxide in up to 5 min. Just 3 % started with the maximum concentration right away, while 28 % need more than 5 min to titrate to the maximum concentration.

Eighty-four percent (84 %) of the cases with nitrous oxide sedation showed no complication. The complications that the dentists observed were of minor severity: 5 % experienced euphoria during treatment, in 2 % of the cases patients had restlessness, 3 % each exhibited sweating, nausea or vomiting. In another 8 % of the cases, patients had other kinds of complications (multiple answers were possible).

The success rate for both dental treatment and minimal sedation with nitrous oxide was 100 % for the patients the dentists had treated last. The patients were also highly satisfied being treated with nitrous oxide, from the dentists' point of view (98 %). Only one dentist reported that the patient was dissatisfied with the treatment. 90 % of the dentists and even 98 % of the patients opted for performing the next dental treatment again with nitrous oxide as minimal sedation.

3.4 View of general dentists on nitrous oxide

The questionnaires were returned by the general dentists selected from the dental registers at a rate of 14 %. All general dentists who responded to the questionnaire knew about the use of nitrous oxide in dentistry. The majority of them (70 %) read about it either in newspapers or in magazines, 53 % knew about it via conferences, 39 % via the internet and only very few via television. However, only a small number of dentists had already used nitrous oxide themselves (17 %).

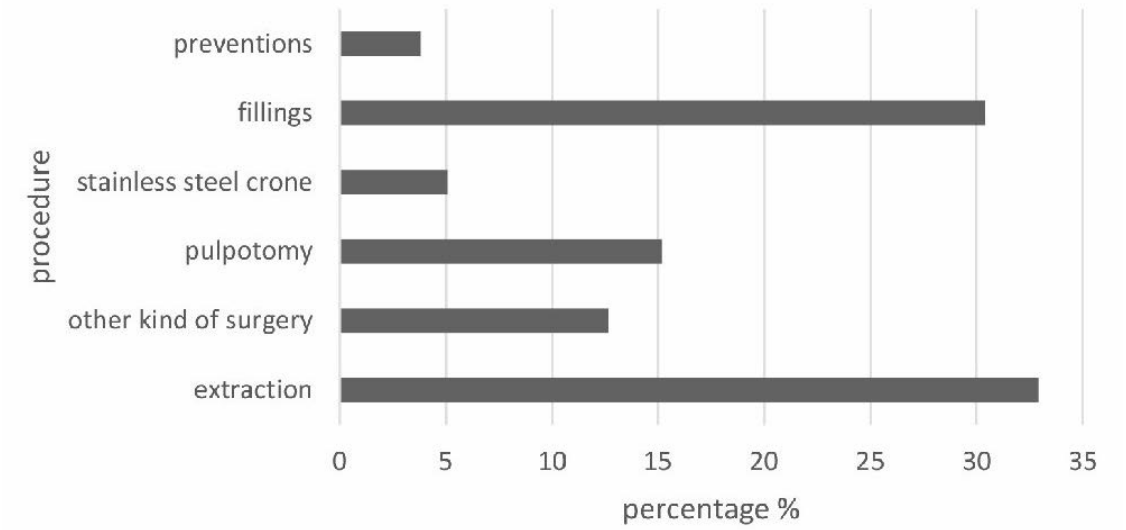
The majority (57 %) of the responding general dentists reported a neutral attitude towards nitrous oxide and the other third thought of it as a positive method. In consequence, 36 % of the responding dentists were undecided about using nitrous oxide in the future, 21 % were willing to use this technique themselves, whereas one third declined this.

In contrast to the large majority (71 %) of the general dentists who refer patients to treatment under general anesthesia, they rejected a referral to another dentist for dental treatment under minimal sedation with nitrous oxide almost unanimously (91 %). As a consequence of negligible inclination to employ nitrous oxide sedation themselves or via a referral, most general dentists performed treatment in uncooperative children under 5 years of age (83 %), patients with a mental handicap (75 %) or anxiety (83 %). On the other hand, the general dentists saw exactly these patients being suited for treatment under nitrous oxide.

4. Discussion

As there was no published data on the use of nitrous oxide in dental practice in Germany, this study allowed a look into this technique which has been revived by the European and German recommendations [20, 21].

The cooperation of the suppliers of nitrous oxide equipment and the randomized collection of German dental registers allowed to select 2 representative samples of general dentists and purchasers of sedation equipment for the first study on the attitudes and use of minimal sedation with nitrous oxide in Germany. As it was a self-report questionnaire, there could be a recall bias



(Fig. 1–4: Authors)

Figure 4 Dental procedures with nitrous oxide sedation in German practices

and a selection bias of dentists, especially in the sample of the general dentists where the response rate was just 14 %. On the other hand, professional questionnaires very often result in low response rates which does not automatically create a non-responder bias [17]. There could be a tendency that especially the questionnaire for general practitioners was answered by dentists who were more in favor or familiar with the nitrous oxide sedation. Dentists without any interest or knowledge could have refrained from answering. Thus, the views and knowledge could be slightly too optimistic compared to all dentists. In contrast to this, the users of nitrous oxide equipment responded at a higher percentage (30 %) and very consistently. Due to the selection by purchasing lists, the long-term users and pioneers of nitrous oxide in Germany who mostly bought their equipment directly from foreign companies would be excluded resulting in a sample of users with reduced years of experience.

4.1 Application standards and training

The application of any health-related technique is judged by its outcome, such as the feasibility of its application, side effects, safety standards, environmental impact and the satisfaction level of its user and the patient. Nitrous oxide sedation has proven to satisfy high standards [1, 5, 11], but its proper application needs skilled handling and suitable equipment. This includes sufficient monitoring of the patient with a pulse oximeter and ventilation which the German dentists fulfilled mostly with additional scavenging systems, but also ventilators or opening the window. Overall, there was good awareness about the safe use of nitrous oxide sedation, as long and chronic exposure might cause unwanted health effects [16, 18, 24]. The mode of usage of nitrous oxide reported by the German dentists minimizes undesirable effects for the dental team through chronic exposure with nitrous oxide [6, 7].

The European guidelines [20] suggest a training course before the use of nitrous oxide by dentists which cover behavior management, physical and biological properties of nitrous oxide and basic life support, besides, 10–12 h of lectures, practical training with 5 observations, assistance and supervised sedation treatments each. Due to the new introduction of nitrous oxide in Germany, there were few certified courses available and the study reveals a broad picture of the training of dentists using nitrous oxide. Still, most of the users (67 %) attended courses for 2 days reflects the duration of the European and German recommendations [20, 21].

4.2 Application technique and maximum concentration

The effective usage of nitrous oxide sedation depends on the proper concentration during its application. The EAPD recommended 30–40 % for adults to reach excellent sedation levels in patients which can be increased during some painful procedure such as extraction and local anesthesia or be reduced during simple ones like restorations [11].

Almost all dentists used a titration technique for finding an individual effective concentration of nitrous oxide. The maximum concentrations within this study were all below 50 % and mostly even in the range of 30–40 %. This minimizes the risk of side effects which is increased with concentrations above 50 % inducing deep sedation or as an anesthetic agent during major surgery [22, 25].

4.3 Indications, frequency of use and referrals

In this part of the study, only 14 out of 100 (14 %) questionnaires were returned. The prime indication for nitrous oxide was anxious patients reported by 95 % of the dentists which is in agreement with observational studies and reviews [1, 11, 12, 20]. This was followed by complex dental treatments (49 %), while non-cooperative children or mentally-handicapped patients were not considered

the main indications for nitrous oxide (20 and 18 %, resp.). In the literature, publications and recommendations on non-cooperative children and pediatric dentistry dominate [11, 21]. But at least in this German study, as in the French one, the use in adults seems to be more frequent [12].

In very few practices, nitrous oxide sedation was a standard procedure for several patients a day (3.3 %). Many dentists used it 1–3 times per month (41.0 %) or even less, which might make it difficult to gain experience which could lead to elevated levels of side effects [13, 25].

Referrals are a key element in specialized dental treatment and, e.g., an Irish study showed that 87 % of general dentists referred children to GA for extractions. As 29 % of the Irish general practitioners had the equipment for minimal sedation with nitrous oxide, the majority of them discussed the sedation as alternative treatment option with their patients and their parents instead of general anesthesia [10]. Nevertheless, the referral rate was high. Similarity in this German study, 71 % of the responding general dentists referred patients to GA, but in contrast to that, none of them referred patients to be treated with nitrous oxide sedation. On the other hand, 71 % of these general practitioners considered non-cooperative children or anxious patients an eligible indication for nitrous oxide, 50 % also patients with a mental handicap and 42 % patients with complex treatment procedures. This also mirrors the actual use of minimal sedation with nitrous oxide in a French study [12].

A shift from treatment under GA to sedation with nitrous oxide could be accompanied by a greater reduction of anxiety [3], possibly through conditioning patients under regular dental treatment modalities which might reduce the need for future GA even further [18].

4.4 Side effects and safety

The general side effects of nitrous oxide sedation are over sedation, vomiting, nausea, dysphoria, sweating, restlessness, panic, headache, nightmares, tinnitus and urinary incontinence [4, 11], while severe emergency situations are very rare [15, 20].

Complications seem to be associated with a long treatment time, high nitrous oxide concentration or rapid changes in the concentration levels of nitrous oxide [19, 20]. As most dentists in the German study employed concentrations well below 50 %, adjusted the individual level slowly via titration and had sedation time of less than 60 min, the chances for unwanted side effects are minimal. This was confirmed by 84 % of the cases without any and euphoria being the most prevalent side effect (5 %). Other complications such as nausea, vomiting, sweating or restlessness were slightly higher than in the equivalent French study [12], but with 2–3 % each rare and of minor severity. No serious complication was noticed and all procedures could be successfully performed, although the dentists might have a slight reporting bias. Still, other studies also report a success rate of 90 % [12].

The elevated rate of side effects could, possibly, be associated with nitrous oxide being a relatively new technique in Germany and some practitioners might still be on a learning curve due to the short time of experience. In addition, the rather infrequent use by some dentists might not be helpful to reach the level of an experienced user who can achieve lower rates of side effects [5, 13]. More standardized training according to the European and German recommendations might be helpful.

In the present study, minimal sedation with nitrous oxide exhibited in German dental practices rarely resulted in mild side effects. Due to the relaxation and the reduced gag reflex, but intact awareness and protective reflexes a high safety level exists in accordance with other studies and reviews [11, 12, 20].

4.5 Patients' and dentists' satisfaction

The satisfaction level of the patients and the dentists were extremely high, exceeding 90 % which mirrors other studies [2, 23]. Thus, they often opted to perform the next treatment also with a nitrous oxide sedation. Especially for anxiety patients this is an important result, but also for strenuous surgical procedures the high level of satisfaction is very interesting [11]. Especially for the group of patients with anxiety that was preferably treated in this study, it can reduce the problem for this subsequent treatment [3].

5. Conclusions

Within the limitations of this study, it can be concluded that German dentists exhibit a positive attitude towards minimal sedation with nitrous oxide. The vast majority of the responding general dentists knew about nitrous oxide from journals, while undergraduate education in the universities did not produce significant experience with nitrous oxide sedation. Still, a considerable number of the responding general dentists (21 %) would be interested in a future use. Interestingly, responding general dentists do not refer special patients to a sedation treatment to another dentist, in contrast to the regular referrals for general anesthesia (71 %).

The vast majority of responding dentists who had purchased the equipment were satisfied or highly satisfied (97 %). Minimal sedation with nitrous oxide was mostly employed for surgical procedures in adults with dental phobia or anxiety.

The success rate of using nitrous oxide was remarkable, both for the sedation and the subsequent treatment according to the reported treatment in the last patient. Even with the risk of a reporting bias, this is still in line with other studies where about 90 % successful treatments could be achieved. As in other studies, very few side effects were reported reaching from euphoria (5 %) to nausea, vomiting or sweating with 3 % or less. No severe side effects or interruptions of the sedation or dental treatment were recorded.

Overall, this study confirms that nitrous oxide is an easy and predictable way to achieve minimal sedation in order to improve dental treatment. Thus, it could be taken into account before a referral to general anesthesia. In accord with the new European and German recommendations, there is a potential that nitrous oxide could be

more widely used in Germany as it is already in other countries.

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Conflict of interest:

The authors state that they have no conflict of interest as defined by the guidelines of the International Committee of Medical Journal Editors.

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