**Exposure of dental staff to nitrous oxide**

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**Abstract**

**Background:** Chronic exposure to nitrous oxide has been reported as a potential health hazard. Leakage from the mask delivery system and inefficient scavenging can lead to significant pollution.

**Aims:** to monitor the nitrous oxide traces in the working environment of the dental staff at the Paediatric Department at of Liverpool Dental Hospital and to compare with the national standards.

**Methods:** Nitrous oxide was measured in twenty seven dental procedures according to two methods. First method, measurements were recorded every two minutes during the inhalational sessions. Second method measurements were recorded from different distances from the operation site.

**Results:** 21 sessions used for the first method. No statistical difference was found between the means of the nitrous oxide traces through the extraction and conservative sessions. Age group from 6 to 8 years has the highest measured traces. High traces recorded during stressful events. 6 sessions were selected for the second method. The distance obeys the inverse square law.

**Conclusions:** Uncooperativeness would lead to excessive pollution. Patient conditioning to breathing through nose would be very helpful. Equipment to be checked for leaks and that the mask is of the appropriate size and tight fitting. Ensure that scavenging and surgery ventilation is adequate.

**Introduction**

For many years, anxiety and fear of dental treatment in children have been recognized as a source of problem in patient management and a variety of behavioural management techniques have been proposed to control such fear reactions to dental procedures.1 Management approaches to anxiety vary according to its severity, the age of the patient, the degree of cooperation and the patient’s medical history.2 The last two decades have seen an increase in the use of sedation in dentistry, which is thought to have contributed to the simultaneous decline in the demand for general anesthesia.3 Inhalation sedation with low-to-moderate concentrations of nitrous oxide in oxygen has a remarkable safety record, in over 45 years of use there has not been any mortality or serious morbidity recorded.4 Inhalation of nitrous oxide is administered via a special nosepiece. The gases are inhaled continually and the nitrous oxide ceases to have effect immediately after cessation of its administration. A patient recovers full consciousness within five minutes after administration of 100% oxygen.5 Chronic occupational exposure to trace concentrations of nitrous oxide has been reported as a potential health hazard,6 but the available evidence is weak and comes mostly from epidemiological studies that have been criticized.7 Some authors reported...
complications to range from haematological abnormalities, neurological deficits, increased risk of spontaneous abortions in women, to a reproductive, mutagenic and carcinogenic effects. These effects can present a serious occupational hazard to dental surgeons and dental nurses who are regularly exposed to nitrous oxide when undertaking inhalation sedation. Leakage of gas from the mask delivery system and inefficient scavenging of waste gas from the surgery atmosphere can lead to significant pollution of the dental surgery.

In the 1990s practitioners have been educated in ways to effectively scavenge trace gas contamination, with the primary method being the evacuation system and the scavenging nasal hood/mask and includes use of the scavenging mask system, evacuation flow rate to be 45 l/per min and any available improved mask designs and/or evacuation devices in addition to regular monitoring programs. British Health and Safety Commission advised that the maximum exposure of clinical staff to nitrous oxide gas should be 100 ppm over an 8 hour time weighted average period. In order for dentists to feel comfortable that they are attaining safe levels of nitrous oxide within their surgeries they should have the ability to monitor the level of the trace gases.

There are many nitrous oxide analysers and dosimeters like the infrared nitrous oxide analyzer which is used in many studies. Several types of dosimeters are available which can be worn as lapel badges during working hours. The purpose of this study was to monitor the nitrous oxide traces in the working environment of the dental staff at variable positions and distances at the paediatric dentistry department of Liverpool Dental Hospital.

Materials and Methods

This is a cross sectional study where ethical approval not required as regular monitoring is part of the safety routine. Furthermore, the activity does not affect the patient’s treatment.

Measurement of nitrous oxide was done in randomly selected twenty seven dental treatments. The treatments were carried out for the child patients attending the paediatric department of the Liverpool Dental Hospital. The patients in the department usually are regular attenders, casual or referred by their GDP’s. Different dental treatments are usually carried out for different patients needs such as for pain relief, managing the anxiety, preventing and treating caries, general anaesthesia, etc. The patients in the department receive various dental treatments such as conservative, extractions, preventive, prosthetic, etc.

One examiner monitored the nitrous oxide traces and he was trained in the use of a nitrous oxide analyzer which is based on the national standards. The Department of Paediatric Dentistry is an open clinic design in which the dental units are separated by short partitions.

Medigas PM3010 N2O Analyser, the features: is a handheld infrared nitrous oxide monitor which can measure nitrous oxide concentrations on the range 0-1,000 ppm with a resolution of 5 ppm. Readings can be displayed in real time or as an 8 hour TWA (Time Weighted Average). The analyser was calibrated and checked by the Medical Engineering Department at the Royal Liverpool Hospital.

The nitrous oxide machine used regularly in the children department at the Liverpool Dental Hospital is the MDM Quantiflex which is a continuous flow type. The machine matches the universal safety measures of the sedation machines. It has the main parts which are the flowmeter, circuit bag, air entrainment valve, scavenging nasal hood and expiratory valve, and the conducting tubes. It uses continuous gas flow and the rate can be adjusted to patient’s minute volume.

The Procedure:

Before the start of each inhalation session, permission was taken from the operators. Also parents and patients were informed about the study and assured that there would be no any intervention with dental treatment.

Nitrous oxide traces were measured in two procedures:

The First Procedure:

In the first procedure, measurements were recorded every two minutes during the inhalational sessions as close as possible to the operation site within a circle of 20 cm diameter. A stopwatch has been used throughout the inhalational sessions from
the time the mask has been placed over the patient’s nose to the time it was removed, during this time nitrous oxide traces were recorded by the Medigas analyzer.

Special forms were used to record the following information:
1. The patient’s age and sex.
2. Nitrous oxide flow (litre per minute) and concentration (in percentage).
3. The nature of the dental treatment such as extraction, conservative, etc.
4. General comments as: whether windows were opened or closed, fan was working or not, etc.
5. In each 2 minute reading, a note will be recorded about the current dental procedure and the patient behaviour as: giving local anesthesia, cavity preparation, extraction, patient is talking, crying, etc.

The Second Procedure:
In this procedure measurements were recorded from different distances from the operation site at zero, one, two, three, four and five metres.

Special forms were used to record the following data:
1. The patient’s age and sex.
2. Nitrous oxide flow (litre per minute) and concentration (in percentage).
3. The nature of the dental treatment such as extraction, conservative, etc.
4. General comments as: whether windows were opened or closed, fan was working or not, etc.
5. In each different distance, a note will be recorded about the current dental procedure and the patient behaviour as: giving local anesthesia, cavity preparation, extraction, patient is talking, crying, etc.

Data Processing
The Analyser will measure nitrous oxide traces in numbers in ppm (part per million) and can be analysed manually and t-test.

Results
Data was collected from 27 paediatric inhalational sessions. In 21 sessions, nitrous oxide traces were measured every 2 minutes throughout the session. In 6 sessions, nitrous oxide traces were measured from different distances from the operation site: at zero, one, two, three, four, and five meters. In all the nitrous oxide inhalation sessions a scavenging nasal mask was used and the fan was working.

A. Measurements taken every 2 minutes during inhalational sessions:
In the 21 sessions, the treatments were 12 extractions (57%), 7 conservative treatments (33%), 1 fluoride application (5%) and 1 as acclimatization (5%). The treatments were carried for 6 males (29%) and 15 female (71%) patients with age ranges from 6 to 17 years, mean is 9.9 years.

The mean nitrous oxide concentration is 30.7% which ranges from 20% to 40% and the mean flow rate is 6.6 l/min which ranges from 5 l/min to 10 l/min. In all the sessions, sampling of the atmosphere was made at 20 cm from the patient in the horizontal plane.

To compare the means of the measured nitrous oxide throughout the extraction sessions and the conservative sessions to see whether the difference is statistically significant or related to sampling errors, we apply t-test, see figure 1.

The calculated t value is 1.12 and the t value from the tables of t distribution for 17 degrees of freedom is 2.11 (p<0.05). Since the calculated t value (1.12) is smaller than the 2.11, then we accept the null hypothesis which states that the difference between the means of the measured nitrous oxide traces through the extraction and conservative sessions is due to sampling errors.

Figure 2 show the relation between the measured nitrous oxide and the patient’s ages. It is obvious that the age group from 6 to 8 years has the highest measured traces of nitrous oxide in the working environment which is 130.17 ppm.

It was clear that high nitrous oxide traces recorded when the patient is having stressful events such as local anesthesia and extraction. Figure 3 shows the measured nitrous oxide traces during an extraction session during 24 minutes. The highest numbers are when the patient had local anaesthesia and during the extraction itself at 14 and 18 minutes respectively. In other sessions such as in session 13, high nitrous oxide traces were measured throughout the entire treatment session, figure 4.

B. Measurements taken at various distances:
Nitrous oxide traces were measured in 6 sessions, 4 sessions were conservative treatment and 2 sessions were extraction, 4 females and 2 males. The mean age of the
patients is 10 years, ranges from 6 to 14 years. The mean nitrous oxide concentration used during the sessions is 31% with a range from 30% to 35%, and the mean flow is 6.2 l/min ranges from 5 l/min to 8 l/min (figure 5).

Discussion

The importance of keeping pollution of nitrous oxide to the absolute minimum levels cannot be understated. The problem is of great concern to the staff who have to work in such an environment constantly, rather than patients where exposure, although at a much higher level to produce the desired clinical effects, is only occasional. There may also be concerns in respect of accompanying adults, e.g. pregnant mothers who may be at the chairside with their child. Problems of chronic exposure to nitrous oxide have been cited in the literature review but the most important ones are haematological changes. Chronic occupational exposure to nitrous oxide may cause depression of vitamin B12 activity and altered DNA synthesis in the bone marrow and mild megaloblastic changes. The aim of this study was to monitor as accurately as possible, the levels of nitrous oxide in the surgery under different conditions. These included continuous monitoring in the immediate vicinity of the operator and also at varying distances.

There was no significant difference between the mean of the measured nitrous oxide traces in the extraction sessions from that in the conservative sessions. This could be attributed to errors in the sampling such as the sample size, randomization, etc, and then we cannot rely on this result to relate the level of nitrous pollution to the type of the dental procedure. It is advisable to do studies with bigger sample sizes to find out the relation between the measured pollution and the type of the dental treatment.

The age group from 6 to 8 years had the highest measured nitrous oxide levels followed by the age group from 12 to 14 years. Even with the sample size being small, we are able to identify a trend of high nitrous oxide levels in younger children. This is likely to result in pollution from expired air as a result of crying, talking etc. or from leakage around the mask due to patient movement etc. These findings are similar to those of Henry et al. who stated that patient behaviour can result in significant increase in nitrous oxide levels in the ambient air.

There are situations that are stressful and cause higher levels of psychological upsets which seem to cause more nitrous oxide pollution at the working site. Examples of such situations have been recorded during monitoring nitrous oxide such as giving local anaesthesia and during the actual extraction procedure. There were a few sessions where nitrous oxide levels reached a very high level, sometimes exceeding 1000 ppm (0.01%). Donaldson and Meechan suggested that when this occurred it was related to leakage of the nitrous oxide sedation machine or cylinders, poorly fitting masks, inadequate scavenging, patient mouth breathing, and poor surgery ventilation. Particular attention to these aspects would be required to ensure pollution is significantly reduced to acceptable levels. The results showed that the higher nitrous oxide levels were recorded at the time when patients were talking, laughing, crying, local analgesia administration, extraction, and rubber dam application.

The results do not show any correlation between the levels of pollution and patient gender or nitrous oxide concentration used. In the latter respect it could be argued that patients who require higher levels of nitrous oxide to effect adequate sedation are those who are more uncooperative. These in turn would be patients who are more likely to cry, talk, move etc. However, it may well be that with a larger sample size such a difference may be more apparent.

It is obvious by looking at the results of the second part that the distance obeys the inverse square law: the nitrous oxide concentration decreases as the distance from working site increases. The greatest nitrous oxide concentrations was at zero metre from the working zone as described by Cleaton-Jones et al. The rapid fall in pollution levels with distance from the working zone is illustrated in figure 5 and this shows that at a distance of approximately 1.5 metres or greater the level is below 100 ppm. This is reassuring for other personnel in the surgery including accompanying parents who are at approximately 2 metres away with level of 50 ppm. Conversely, concerns are raised in respect of the operator and
assisting dental nurse who are in the working zone during these administrations. There is no doubt that for many patients, nitrous oxide sedation provides a good quality of sedation for them to be able to cope with treatment. This study has highlighted potential problems in respect of nitrous oxide pollution which is of concern to all personnel in surgery during the sedation sessions.

1. In this study the sample size was very limited. A future study with a larger cohort would be much more meaningful and would, hopefully, confirm the trends which I have found.

2. Patient selection is of utmost importance as a struggling, crying child would lead to very excessive pollution.

3. Patient conditioning to breathing through his/her nose at all times would be very helpful. Talking to patients through (with the help of normal behavioral management techniques) stressful events e.g. local analgesia administration, extractions, etc. would limit the amount of disruption and the pollution at these times.

4. Ensure equipment is checked for leaks and that the mask is of the appropriate size and tight fitting.

5. Ensure that scavenging and surgery ventilation is adequate.

References


14. Guidelines for the Safety of Employees Exposed to Anaesthetic Gases and Vapours, University of Wales, College of Medicine, 2002.


Figure 1. Relation between type of dental procedure and amount of N2O pollution.

Figure 2. Relationship between patient age and amount of N2O pollution.

Figure 3. Amount of N2O traces during dental extraction.
Figure 4. Amount of N\textsubscript{2}O traces in dental session 13.

Figure 5. Relationship between N\textsubscript{2}O traces and distance.