Environmental monitoring of nitrous oxide during dental anaesthesia

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Aim The study was carried out to see if levels of nitrous oxide in dental theatres and community dental clinics were being controlled in accordance with the Control of Substances Hazardous to Health Regulations.
Setting A multi-centre study looked at exposure levels in a dental teaching hospital and two community dental clinics in the South Wales area between 1997 and 1998.
Methods A MIRAN infra-red spectrophotometer was used to measure static levels of nitrous oxide during general anaesthesia and conscious sedation. NIOSH method 6600 was used to collect personal samples of the individual administering the anaesthetic.
Results The results showed compliance with the regulations when averaged out over an 8 hour time weighted average. However, over short periods of time peak concentrations of up to 1190 ppm were observed through static sampling, and up to 734 ppm through personal sampling.
Conclusions The results highlighted the need to provide adequate control measures such as anaesthetic gas scavenging, to reduce occupational exposure to dental staff in dental operating theatres and community dental clinics, therefore providing a safe working environment.

Nitrous oxide is still widely used in both dental theatres and community dental clinics. Many of these areas, especially community dental clinics, were not designed for the use of anaesthetic agents and therefore do not have the necessary ventilation and anaesthetic gas scavenging available to them. This may result in dentists and dental assistants being exposed to levels above the occupational exposure limit of 100 ppm over an 8 hour time weighted average (TWA) set by the Health Services Advisory Committee (HSAC)[1] which came into force on the 1 January 1996.

There is concern relating to high occupational exposures since nitrous oxide is known to exert a number of effects.

Megaloblastic changes are reported in individuals with prolonged clinical exposures[2] and interference with DNA synthesis has been reported for patients exposed for 2–4 hours.[3]

Although N_2O is teratogenic in rats at high doses,[4] evidence of reproductive effects in humans is equivocal. Early studies on spontaneous abortion in operating theatre staff[5–7] as well as dated and recent surveys of dental assistants[8,9] or midwives[10] do not permit accurate risk estimation. There is no evidence of increased risk of malignancy in exposed personnel.[11]

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Environmental monitoring

In a dental hospital, a total of 12 static monitoring sessions were carried out in the dental operating theatres and 7 in the recovery room. The sterile dental theatre was used for surgical procedures during the mornings and the minor procedures theatre was used in the afternoons with the majority of patients being paediatric cases. A total of 11 personal samples were taken from anaesthetists in theatre and 6 from staff in the recovery room.

The sterile dental theatre and the minor procedures theatre were adjoining rooms and access to the recovery room was via the minor procedures theatre.

Prior to the monitoring, the level of ventilation and the provision of anaesthetic gas scavenging was established. Air change measurements were carried out in both theatres and the recovery room using method MDHS 73[12] as approved by the Health and Safety Executive. At the time of monitoring there was limited gas scavenging in the theatre areas but no provision of anaesthetic gas scavenging in the recovery room, the number of air changes in these areas were marginally below the recommended minimum level of 15 air changes per hour.[13] No air change measurements were carried out in the community clinics because of time and financial constraints.

Patients were anaesthetised in the operating theatre. During monitoring in the sterile theatre, nasal masks were used, anaesthetic induction was by a combination of intravenous drugs and nitrous oxide, although on a few occasions only gaseous inductions were carried out. A circle system was used in the sterile theatre where procedures had a longer duration.

In the minor procedures theatre laryngeal masks were used in general, although on a number of occasions a facemask was used if the procedure was expected to last a very short time. It was observed that, as with the sterile theatre, in general anaesthetic induction was carried out by a combination of intravenous drugs and anaesthetic gas, notably nitrous oxide.

Static monitoring was carried out using a Foxboro MIRAN infrared spectrophotometer. This was positioned in each of the areas to obtain a sample of the atmosphere in the working environment. Each monitoring session was carried out for the duration that nitrous oxide was being used.

Personal sampling was carried out using a Negretti personal sampling pump attached to a 1 litre gas reservoir bag, following the National Institute of Occupational Safety and Health (NIOSH) analytical method 6600.[14] The pump and bag were attached to the dentist where relative analgesia was being used, and were on the anaesthetist where general anaesthesia was being undertaken.

A total of four static monitoring sessions were carried out in community dental clinics: one during a general anaesthetic list and three during conscious sedation. No active anaesthetic gas scavenging was present and no provision was made for increased ventilation in these areas. A total of six personal samples were taken during the monitoring in the community dental clinics: three during conscious sedation and three during general anaesthetics.

Table 1 Static monitoring of nitrous oxide in dental theatres (general anaesthesia)

Area	Peak level (ppm)	Average level (ppm)	Time (mins)
Sterile theatre	140	36	180
	300	35	150
	6	3	120
	575	163	150
	320	41	150
	1190	467	120
	375	118	90
	325	49	210
	875	327	70
	675	352	30
	330	67	150
	250	67	90
Minor procedures	375	118	40
	300	35	30
	400	119	120
	475	132	150
Recovery room	4	2	60
	275	58	120
	375	134	180
	225	78	90
	90	50	120
	18	7	90
	70	33	50

Table 2 Static monitoring of nitrous oxide in community dental clinics

Area	Peak level (ppm)	Average level (ppm)	Time (mins)
Clinic 1 (CS)	700	277	180
Clinic 2 (CS)	650	81	240
	42	20	60
Clinic 3 (GA)	560	177	130

CS = conscious sedation
GA = general anaesthetic

Results

In theatres for five of the sessions monitored the static TWA environmental level over the session period exceeded the OES level although this was only the case for one session in the recovery room (see Table 1). Only one personal sample exceeded the OES over the time monitored.

A community dental clinic (Clinic 1) was monitored which did not have increased ventilation or the provision of anaesthetic gas scavenging. During this time six patients were treated using conscious sedation. The TWA over 180 minutes was 277 ppm although a peak level of 700 ppm was recorded. Personal sampling was also carried out in the community dental clinic (Clinic 1). Three Personal samples were taken from the dentist carrying out the conscious sedation. The mean level was calculated at 19 ppm range (0–40ppm), see Table 4.

A clinic run within the dental hospital (Clinic 2) was also monitored on two occasions. This was an open plan treatment area with many different work areas. On the occasions monitored only one patient was being treated under conscious sedation, the first static monitoring result shows the TWA over 240 minutes as 81 ppm with a peak level of 650 ppm. The second result shows a TWA over 60 minutes of 20 ppm with a peak level of 42 ppm. No personal sampling was undertaken in this area.

In a community dental clinic (Clinic 3), run on a weekly basis within a hospital, during a general anaesthetic list with 13 children being treated. The peak static level recorded of nitrous oxide was 560 ppm, with an average level of 177 ppm being calculated over the duration of the 130 minutes monitoring time. Although this was a community clinic, it was based within a hospital environment and therefore an anaesthetist was present to administer the general anaesthetic. Personal samples from the anaesthetist show a mean level of 299 ppm range (20–734 ppm).

The results in both the dental theatres monitored and the community clinics show that high levels of nitrous oxide are present during the dental procedures being carried out. Personal exposure levels measured show that levels are high in the community clinic using general anaesthetics.

Discussion

The survey results indicate that staff exposures in operating theatres and community dental clinics were high on some occasions.

It was observed from the environmental monitoring undertaken, that where dental procedures are being carried out on children there is a very high throughput over a relatively short period of time. The procedures carried out often only require the child to be anaesthetised for very short periods of time. This leads to large amounts of waste anaesthetic gas being present in the working atmosphere of the operating theatre or treatment room.

This is highlighted in the results. Three different areas were monitored, the first being a sterile dental theatre where more lengthy procedures are carried out. This theatre is used during the morning with an average of 3 persons being treated. The afternoon operating session takes the form of a clinic with a high throughput of young children being anaesthetised for the removal of teeth. Up to 13 children may be treated in any one afternoon in this theatre.

It is recognised that the use of nitrous oxide in the operating theatre environment is in decline,[15–18] however it is still very much used in the dental environment. The possibility of using xenon gas as an anaesthetic gas has also been suggested although its cost precludes its widespread use.[19]

Table 3 Personal sampling of healthcare staff exposed to nitrous oxide during dental procedures in a dental hospital (general anaesthesia)

Area	Level (ppm)
Sterile theatre	10
	59
	4
	12
	36
	20
	8
	28
	17
	72
Minor procedures	122
	94
Recovery room	10
	8
	4
	8
	10
	10
	38
	26
	44

All personal samples were taken over a period of 20 minutes

Table 4 Personal sampling of healthcare staff exposed to nitrous oxide during dental procedures in community clinics

Area	Level (ppm)
Clinic 1 (CS)	0
	40
	17
Clinic 2 (CS)	
Clinic 3 (GA)	20
	143
	734

All personal samples were taken over a period of 20 minutes
CS = conscious sedation
GA = general anaesthetic

A recent report by the General Dental Council[20] highlighted that both conscious sedation and general anaesthesia must only be carried out in areas where suitable equipment and adequate facilities are available and only by an individual specifically trained to the requirements of the Royal College of Anaesthetists. Standards for General Anaesthesia in dentistry, published by the Royal College of Anaesthetists, questions the need for such a high proportion of procedures carried out under general anaesthesia in the UK[21] but the report fails to point out the importance of controlling exposure to anaesthetic agents in areas carrying out general anaesthesia.

The provision of anaesthetic gas scavenging is an essential element in the control of exposure. The introduction of gas scavenging can reduce the amount of pollution from waste anaesthetic gases by as much as 90% or more.[22,23] Where necessary anaesthetic gas scavenging should be installed to ensure that levels of waste anaesthetic are within the standards set by the Control of Substances Hazardous to Health (COSHH) Regulations 1999.[24]

Active anaesthetic gas scavenging systems should comply with the British Standard 6834: 1987 'Active Anaesthetic Gas Scavenging Systems'. There are specific pieces of equipment that deal with this issue in a dental environment, with manufacturers including McRea Engineering and Anaesthetic Pollution Control (APC). These systems are designed to provide effective scavenging in both a theatre and dental clinic environment.

It is also important that finances are made available to dental clinics to enable them to ensure that where anaesthetic agents are being used, adequate ventilation is provided.

Tests should also be carried out to ensure there is the correct number of air changes in the area using anaesthetic agents. Theatre and recovery areas should have 15 air changes per hour.[6] Areas using conscious sedation should have a minimum of 6–7 air changes per hour.[1] Where control measures are in place it is essential that they be maintained every 14 months in conjunction with the COSHH Regulations. It is also recommended that where nitrous oxide is being used that this also should be monitored on an annual basis.

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