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The use of nitrous oxide in paediatric anaesthetic practice in the United Kingdom: a questionnaire survey*

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Summary

Nitrous oxide pollution is common in paediatric anaesthetic practice. A questionnaire was sent to all UK members of the Association of Paediatric Anaesthetists requesting details of three areas of their paediatric practice relating to nitrous oxide: attitudes to its use; current usage; and availability of alternatives. Replies were received from 296 (68%) consultants. Of these, 169 (57%) stated that their use of nitrous oxide had decreased over the last 5 years. One hundred and fifty-eight (54%) considered theatre pollution a problem in paediatric anaesthesia. One hundred and sixty-nine (57%) reported that in normal circumstances potential deleterious effects on patients influenced their use of nitrous oxide, whilst only 70 (24%) felt potential effects on staff influenced usage. Fifty-five (18%) felt there should be some restriction in the availability of nitrous oxide.

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Paediatric anaesthetists are more likely than those in adult practice to perform gaseous inductions and use unscavenged breathing systems. Control of Substances Hazardous to Health (COSHH) Regulations 1999 state that 'exposure to anaesthetic agents must be reduced to as low as reasonably practicable' [1]. Previous studies have shown exposure to waste anaesthetic gases during paediatric operating lists to be high, especially during inhalational induction [2] and also in non-theatre areas [3] where paediatric anaesthetists may frequently operate.

The Health and Safety Commission Advisory Committee on Toxic Substances has examined the evidence available on toxic effects of anaesthetic agents and introduced Occupational Exposure Standards for nitrous oxide of 100 ppm over an 8-h time weighted average [4]. Employers have a legal duty to monitor, control and maintain the nitrous oxide exposure of their employees below this level.

Occupational exposure to nitrous oxide is considered a health and safety issue by the authorities and attempts to minimise exposure should be made. In view of the legislation already described and the costs involved in monitoring levels of nitrous oxide and maintaining equipment, this questionnaire survey was designed to determine attitudes, usage and availability of alternatives to nitrous oxide in paediatric anaesthetic practice in the UK.

Methods

A questionnaire was developed asking 16 questions in three areas: attitudes to the use of nitrous oxide; to what extent nitrous oxide was utilised; and the availability of alternatives (Appendix 1). A question on gender was included to ascertain whether the female-orientated health issues [5–7] associated with pollution exposure in the operating theatre were influencing attitude to usage of nitrous oxide. A total of 433 questionnaires were sent with a covering letter and a prepaid envelope to all non-retired UK members of the Association of Paediatric Anaesthetists (APA). All APA members are consultant anaesthetists and therefore this body was guaranteed to have at least 5 years' anaesthetic experience. The results from the returned questionnaires were entered into a

spreadsheet and then analysed by the χ^2 test using SPSS v.12.0, with statistical significance taken at $p < 0.05$.

Results

One questionnaire was returned from a retired anaesthetist and discarded, leaving a total of 296 valid returned questionnaires, a 68% response rate. Of the respondents, 169 (57%) were male, 100 (34%) female and 27 (9%) did not state gender. Mean (SD) length of time in clinical anaesthesia was 12 (7.2) years, with 156 (53%) having ≥ 10 years' clinical experience. One hundred and fifty-five (52%) respondents performed four or more paediatric sessions per week and the median (IQR [range]) number of sessions was 4 (2–6 [1–12]). Attitudes to the use of nitrous oxide are shown in Table 1. Female anaesthetists were more likely to have decreased nitrous oxide usage than males (63 (63%) and 93 (55%), respectively), although this difference was not significant ($p = 0.331$). They were significantly more likely than their male counterparts to consider deleterious effects on patients during routine practice ($p = 0.006$). Eighteen percent of consultant paediatric anaesthetists felt that there should be some restriction on the availability of nitrous oxide.

Usage of nitrous oxide and availability of alternatives are shown in Tables 2 and 3, respectively. There were no gender differences.

Table 1 Attitudes to use of nitrous oxide amongst paediatric anaesthetists. Values are number (proportion).

Q1 Use of nitrous oxide in last 5 years	
Increased	2 (0.7%)
Decreased	169 (57%)
Stayed the same	122 (41%)
Not answered	3 (1%)
Q2 Pollution with nitrous oxide a problem	
Yes	160 (54%)
No	132 (45%)
Not answered	4 (1%)
Q3 Use influenced by deleterious effects on patients	
Yes	169 (57%)
No	124 (42%)
Not answered	3 (1%)
Q4 Use influenced by deleterious effects on staff	
Yes	70 (24%)
No	224 (76%)
Not answered	2 (0.7%)
Q5 Acceptable level of restriction on nitrous oxide	
Unavailable	16 (5%)
Available on request	39 (13%)
Freely available	234 (79%)
Not answered	7 (2%)
Q6 Use avoided in areas with < 15 air changes.h^{-1}	
Yes	63 (21%)
No	213 (72%)
Not answered	20 (7%)

Table 2 Usage of nitrous oxide by paediatric anaesthetists. Values are number (proportion).

Q1 During induction	
Frequently	218 (74%)
Occasionally	53 (18%)
Never	24 (8%)
Not answered	1 (0.3%)
Q2 Open system during induction	
Frequently	234 (79%)
Occasionally	51 (17%)
Never	10 (3%)
Not answered	1 (0.3%)
Q3 During maintenance	
Frequently	203 (69%)
Occasionally	67 (23%)
Never	25 (8%)
Not answered	1 (0.3%)
Q4 Open system during maintenance	
Frequently	73 (25%)
Occasionally	141 (48%)
Never	81 (27%)
Not answered	1 (0.3%)
Q5 T-piece adapted for scavenging	
Frequently	103 (35%)
Occasionally	78 (26%)
Never	92 (31%)
Not answered	23 (7%)

Table 3 Availability of alternatives to nitrous oxide amongst paediatric anaesthetists. Values are number (proportion).

Q1 No. of anaesthetic machines with air	
All	209 (71%)
Some	84 (28%)
None	2 (0.6%)
Not answered	1 (0.3%)
Q2 Use of total intravenous anaesthesia	
Frequently	15 (5%)
Occasionally	174 (59%)
Never	103 (35%)
Not answered	4 (1%)
Q3 Equipment for total intravenous anaesthesia	
Yes	142 (48%)
No	144 (49%)
Not answered	10 (3%)
Q4 Supplementation during total intravenous anaesthesia	
Oxygen/air	165 (55%)
Oxygen/nitrous oxide	31 (10%)
Not answered	100 (34%)

Discussion

Lassen et al. published the first observations of the adverse effects of nitrous oxide in 1956 [8], noting bone marrow depression in patients with tetanus who had been ventilated with a 50% mix of nitrous oxide and oxygen. Later, a Russian doctor, Vaisman, published data suggesting a much higher incidence of abortions amongst 110 female anaesthetists [9]. Studies undertaken in the

1970s into the outcome of pregnancy among theatre workers led to Department of Health guidance recommending improvements in the ventilation of operating theatres and the introduction of scavenging systems. Methodological criticisms of early work and subsequent studies including a large (12 086) prospective study among female anaesthetists and other female doctors in the UK tended to dispel concern regarding exposure to nitrous oxide [10]. However, in 1992 the issue was raised again when Rowland et al. published a study demonstrating a significant risk of reduced fertility in female dental assistants exposed to nitrous oxide for ≥ 5 h per week [11]. Animal studies have demonstrated adverse effects including teratogenicity in rats [12].

Arguably, the benefits of using nitrous oxide are no longer relevant with the advent of modern agents like remifentanil and sevoflurane. Some perceived benefits may be overstated. For example, nitrous oxide is purported to speed induction of anaesthesia via the second gas effect but this has not been consistently borne out by clinical studies [13].

The continued use of nitrous oxide has been the subject of controversy, with one high profile case raising important safety questions. In November 2000, a 3-year-old girl died in the Accident and Emergency Department of a London hospital [14]. She had mistakenly been given pure nitrous oxide instead of oxygen. As a direct result of this death, in 2001 The Medical Devices Agency (now the Medicines and Healthcare products Regulatory Agency) issued a safety notice – SN (2001) 15 – asking all trusts to ensure that machines had either hypoxic guards or oxygen analysers with audible alarms [15]. Although there were several issues surrounding this case, the fact remains that if there was no nitrous oxide on anaesthetic machines, no hypoxic mixture could have been given to an obtunded patient. Our current questionnaire has highlighted the fact that certain hospitals are 'nitrous free'. Although this may be a step too far for some, perhaps a step towards anaesthetic machines' being 'nitrous free' would be a sensible compromise. Notably, approaching 1 in 5 practising paediatric anaesthetists surveyed felt there should be some restriction on the availability of nitrous oxide.

This survey confirmed that paediatric patients are frequently anaesthetised in locations such as dental theatres, radiology suites and oncology departments where it may be more difficult to comply with set exposure limits when compared to the theatre environment [16, 17]. These lists are also likely to have a higher turnover and this will increase exposure of staff to waste anaesthetic gases including nitrous oxide. The problem is not confined to theatre staff, as Henderson and Matthews [3] found high personal exposure of staff in recovery rooms.

Our results show that most paediatric anaesthetists feel that nitrous oxide is still a valuable part of clinical anaesthesia. However, 57% of respondents reported that their use of the gas had decreased over the past 5 years. Reduction in the use of nitrous oxide would appear to be largely because of medical indications and to a much lesser extent due to concerns over pollution and effects on other staff.

Generally, the responses indicated that a significant proportion of consultant paediatric anaesthetists (54%) who took part felt that nitrous oxide pollution in paediatric anaesthesia was a problem, despite the greater use of circle systems and anaesthetic gas scavenging. This contrasts with a previous UK survey of the use of nitrous oxide in anaesthetic practice published in 2002 (including both adult and paediatric anaesthetists), in which only 16% of responders felt that operating theatre pollution by nitrous oxide was a problem [18]. In the previous questionnaire, 80% of senior anaesthetists felt that nitrous oxide should remain freely available. Our figures for consultant paediatric anaesthetists are comparable at 79%.

In this UK survey, 73% of paediatric anaesthetists reported they frequently used nitrous oxide during gaseous induction of anaesthesia in children and 80% frequently do so with an open circuit. In a survey conducted in New Zealand and reported by Sharples in an editorial on the use of nitrous oxide in paediatric anaesthetic practice [19], approximately 60% of respondents used a nitrous oxide : oxygen mixture as their standard for gaseous induction. In addition, 50% of New Zealand public hospitals had not conducted environmental monitoring of anaesthetic waste gases in the last 4 years. The author comments that 'these figures appear alarming – particularly to those in a highly regulated first world health system'. Sharples clearly feels that the approach of the New Zealanders should shock the rest of the anaesthetic community in the developed world. However, the UK paediatric anaesthetist's view of nitrous oxide appears to be even more liberal than their New Zealand counterparts. Given the recommendations of the COSHH regulations [1], should we still be using nitrous oxide?

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Appendix 1: Questionnaire: The use of nitrous oxide in paediatric anaesthetic practice

Sex Male/Female
Years in paediatric anaesthesia..... No. of paediatric anaesthesia sessions per week.....

Please circle answers and answer questions in relation to your PAEDIATRIC PRACTICE ONLY.

ATTITUDES TO USE OF NITROUS OXIDE

1. Over the last 5 years, has your use of nitrous oxide in paediatric anaesthesia:
   (a) Increased b) Decreased c) Stayed the same
2. Do you think that operating theatre pollution by nitrous oxide is a problem in paediatric anaesthesia despite the increased use of circle systems and scavenging systems?
   (a) Yes b) No
3. In normal circumstances is your use of nitrous oxide influenced by potential deleterious effects on your paediatric patients?
   (a) Yes b) No
4. Has your use of nitrous oxide for children been influenced by the effect of pollution on staff?
   (a) Yes b) No
5. Taking into consideration clinical usage and environmental pollution concerns, what level of restriction of the use of nitrous oxide use would be acceptable?
   (a) Unavailable b) Available on request c) Freely available

   Please comment.....
6. Do you avoid using nitrous oxide in areas with less than 15 air changes per hour?
   (a) Yes b) No

USE OF NITROUS OXIDE

1. Do you use nitrous oxide for INDUCTION of anaesthesia in children?
   (a) Frequently b) Occasionally c) Never
2. Do you use an open circuit such as a T piece for gaseous induction?
   (a) Frequently b) Occasionally c) Never
3. Do you use nitrous oxide during maintenance of anaesthesia for children?
   (a) Frequently b) Occasionally c) Never
4. Do you use an open circuit such as a T piece during maintenance?
   (a) Frequently b) Occasionally c) Never
5. Do you use a T piece with an adaptation for scavenging?
   (a) Frequently b) Occasionally c) Never
   Please comment:.....
6. Where do you commonly perform gaseous induction of children (you may circle more than one)?
   (a) Anaesthetic Room b) Theatre c) Other

ALTERNATIVES TO NITROUS OXIDE

1. How many of the anaesthetic machines you use for paediatric anaesthesia have medical air?
   (a) All b) Some c) None
2. Do you use TIVA for paediatric anaesthesia?
   (a) Frequently b) Occasionally c) Never
3. Is equipment for TIVA appropriate for paediatric use freely available in your hospital?
   (a) Yes b) No
4. If you use TIVA in paediatric anaesthesia, do you supplement anaesthesia with:
   (a) oxygen/air b) oxygen/nitrous oxide