

# How green is my operation theater?

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## ABSTRACT

**Objective:** To ascertain the awareness regarding global warming and the anesthesia practices contributing to it in the city of Delhi. **Materials and Methods:** A questionnaire was circulated amongst the qualified anesthesiologists (consultants and senior residents) in the city of Delhi. The initial contact was made through e-mail and the questionnaire was required to be filled and returned electronically. The questionnaire was also made available online at <http://sites.google.com/site/surveydelhi>. After 1 month, the forms were distributed physically. Assuming that at least 50% of the approximately 1200 practising anesthesiologists would be able to recognize the greenhouse gases correctly, the target number of responses was 150 with 99% confidence limit. **Results:** Of the 831 anesthesiologists contacted, only 184 responded. Ninety-eight percent were aware of the greenhouse effect, but only 15.8% (29) could correctly identify all the greenhouse gases. However, 47.28% (87) could identify nitrous oxide and inhalational agents as a cause of greenhouse effect. Ninety percent of the respondents use circle system and 87% use low flows frequently. Ninety-three percent (171) of respondents routinely use nitrous oxide, and 32.1% (59) would, however, not use air even if made available. Seventy-nine percent (145) advocated total intravenous anesthesia as an alternative to reduce the menace. **Conclusion:** Only 22% were motivated enough to respond to the survey. More than half of these anesthesiologists were not aware about the anesthetic agents contributing to the greenhouse effect. However, their clinical practices inadvertently do not add to the environmental pollution.

**Key words:** Environment, greenhouse effect, survey, volatile anesthetics

## INTRODUCTION

There is an increasing concern about pollution of the atmosphere due to human activities. Whether it is the traffic spewing exhaust fumes or the stench that emanates from once upon a time river along the city! It is either too hot or too cold. Experts call it global warming, owing to the greenhouse effect.

All the volatile anesthetics that are currently used (halothane, isoflurane, enflurane, sevoflurane, and desflurane) are halogenated compounds potentially destructive to the ozone layer.<sup>[1]</sup> The widely used anesthetic gas nitrous oxide (N<sub>2</sub>O) is an established greenhouse gas.<sup>[2,3]</sup> A recent report suggests that N<sub>2</sub>O is also an important ozone-depleting

gas.<sup>[4]</sup> Anesthesiologists are thus equal contributors, thanks to the widespread use of these gases.

We designed a simple questionnaire to help us estimate the awareness regarding this issue and anesthesia practices in the National Capital Territory of Delhi (India) and the measures undertaken to reduce harmful effects of anesthetic gases on climate.

## MATERIALS AND METHODS

After obtaining approval from the Research and Protocols Committee, a questionnaire (Appendix) containing 19 items was circulated amongst the qualified anesthesiologists in the city of Delhi. The questionnaire included awareness regarding greenhouse effect, gases responsible, facilities available in their setup, and anesthesia practices that can have an impact on countering this menace. The list and e-mail addresses of the practising anesthesiologists were obtained from the Indian Society of Anaesthesiologists (Delhi branch) website ([www.isadelhi.com](http://www.isadelhi.com)). The initial contact was made through e-mail, and the questionnaire was sent as an attachment which was required to be filled and returned electronically. The questionnaire was also

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	DOI: 10.4103/1658-354X.140860

**APPENDIX \*Required**

1. Number of operating tables in the hospital\*
  - a. 2
  - b. 3-5
  - c. 6-10
  - d. 11-20
  - e. >20
2. Number of operating tables you are responsible for\*
  - a. 1
  - b. 2
  - c. 3
  - d. 4
  - e. >4
3. Are you aware of the greenhouse effect?\*
4. Greenhouse effect is related to\* (more than one option)
  - a. CO<sub>2</sub>
  - b. N<sub>2</sub>O
  - c. CH<sub>4</sub>
  - d. Halogenated inhalational agents
  - e. CFC
5. Do you have laminar air flows in the OTs?\*
6. Do you have a scavenging system?\*
7. If yes, whether<sup>1/4</sup>
  - a. Active
  - b. Passive
8. Which type of breathing circuit do you use?\*
9. If closed circuit, how often?
  - a. Always
  - b. Frequently
  - c. Occasionally
  - d. Rarely
  - e. Never
10. Do you use low gas flows?
  - a. Yes
  - b. No
11. How much flow do you usually use?\*
12. How often do you use low gas flows?
  - a. Always
  - b. Frequently
  - c. Occasionally
  - d. Rarely
  - e. Never
13. You routinely use...\*
  - a. N<sub>2</sub>O
  - b. Air
14. How often do you use air?
  - a. Always
  - b. Frequently
  - c. Occasionally
  - d. Rarely
  - e. Never
15. You do not use air because<sup>1/4</sup>
  - a. Not available
  - b. Increased requirement of opioids
  - c. Not comfortable
16. If air was available in your theater, would you prefer it over nitrous oxide?\*
17. Which agent do you think contributes the most to the greenhouse effect?\*
18. General anesthetic technique which can minimize greenhouse effect<sup>1/4</sup>\*
19. How often do you use TIVA?\*

made available on the website <http://sites.google.com/site/surveydelhi>. A period of 1 month was allotted for online submission. After this time period, the forms were distributed physically in various hospitals to target anesthesiologists who had not participated online. All information that was provided remained confidential. At no point was anyone asked to disclose his/her identity. Data collected included the percentage of anesthesiologists correctly identifying greenhouse gases (GHG), preferring air over N<sub>2</sub>O, using closed circuit and low to very low flows, and using total intravenous anesthesia (TIVA).

**Statistical analysis**

Sample size was calculated using OpenEpi, Version 2, open source calculator (SSPropor: <http://www.openepi.com/OE2.3/SampleSize/SSPropor.htm>). There are approximately 1200 practising anesthesiologists in Delhi. Assuming that 50% ( $\pm 10\%$ ) of the anesthesiologists will correctly identify the GHG, a sample size of

146 participants was required with confidence limits of 99% and a design effect of 1.0. We aimed to include at least 150 anesthesiologists. Data collected and analyzed included percentage of participants correctly identifying GHG, and using air, closed circuit, low to very low flows, and TIVA. Chi-square test was used for analysis and a  $P < 0.05$  was taken as significant.

**RESULTS**

Of the 831 anesthesiologists contacted, only 184 (22.14%) responded. Ninety-eight percent were aware of the greenhouse effect, but only 29 (15.8%) could correctly identify all the GHG. However, amongst the gases which concern us, 40 (21.7%) respondents could identify only N<sub>2</sub>O, 27 (14.7%) only inhalational agents, and 87 (47.28%) could identify both as a cause of greenhouse effect. Only 18.5% could recognize desflurane as the gas with maximum

greenhouse warming potential (GWP). Ninety percent of the respondents use circle system and 87% use low flows frequently. Hundred and seventy-one (92.9%) of the respondents routinely use N<sub>2</sub>O. Fifty-nine (32.1%) would, however, not prefer air even if made available to them. One hundred and forty-five anesthesiologists (78.8%) advocated TIVA as an alternative to reduce the menace. The results are depicted in Table 1.

## DISCUSSION

Industrialization and human development in the last 100 years has led to an increase in concentration of GHG in the atmosphere and an increase in mean surface temperature of the earth.<sup>[5]</sup> The major long-lived GHG include CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, and halogenated organic compounds. The destructive potential of chlorofluorocarbons (CFC) and

**Table 1: Responses to the questionnaire**

Question	Number of respondents	Responses					P value
Number of operating tables in the hospital	184	2	3-5	6-10	11-20	>20	<0.01
		13 (7.1%)	31 (16.8%)	50 (27.2%)	67 (36.4%)*	23 (12.5%)	
Number of tables you are responsible for	184	1	2	3	4	>4	<0.01
		98 (53.3%)*	54 (29.3%)	7 (3.8%)	13 (7.1%)	12 (6.5%)	
Are you aware of greenhouse effect?	184		Yes	No			<0.01
			181 (98.4%)*	3 (1.6%)			
Greenhouse effect is related to %	184	CO <sub>2</sub> , N <sub>2</sub> O, CH <sub>4</sub> , inhalational agents, CFC	N <sub>2</sub> O alone and/or other gases	Inhalational agents and/or other gases	N <sub>2</sub> O+inhalational agents and/or other gases		<0.01
		29 (15.8%)*	127 (69.02%)	114 (61.95%)	87 (47.28%)		
Do you have laminar air flows in the OT?	184		Yes	No			0.15
			87 (47.3%)	97 (52.7%)			
Do you have a scavenging system?	184		Yes	No			<0.01
			59 (32.1%)	125 (67.9%)*			
If yes, whether...	184		Active	Passive			0.14
			26 (14.1%)	33 (17.9%)			
Which type of breathing circuit do you use?	184		Bain's (semi-open)	Circle (closed)	Any other		<0.01
			19 (10.3%)	165 (89.7%)*			
If closed circuit, how often?	184	Always	Frequently	Occasionally	Rarely	Never	<0.01
		95 (51.6%)*	77 (41.8%)	3 (1.6%)	1 (0.5%)	8 (4.3%)	
Do you use low gas flows?	184		Yes	No			<0.01
			169 (91.8%)*	15 (8.2%)			
How much flow do you usually use?	184	>4 l/min	2-4 l/min	1-2 l/min	<1 l/min		<0.01
		13 (7.1%)	37 (20.1%)	114 (62%)*	20 (10.9%)		
How often do you use low gas flows?	184	Always	Frequently	Occasionally	Rarely	Never	<0.01
		61 (33.2%)	98 (53.2%)*	12 (6.5%)	5 (2.7%)	8 (4.3%)	
You routinely use...	184		N <sub>2</sub> O	Air			<0.01
			171 (92.9%)*	13 (7.1%)			
How often do you use air?	183	Always	Frequently	Occasionally	Rarely	Never	<0.01
		3 (1.6%)	24 (13%)	36 (19.6%)	31 (16.8%)	89 (48.4%)*	
You do not use air because...	184		Not available	Increased requirement of opioids	Not comfortable		<0.01
			115 (62.5%)*	37 (20.1%)	22 (12%)		
If air was available, would you prefer it over N <sub>2</sub> O?	180		Yes	No			<0.01
			125 (67.9%)*	55 (29.9%)			
Which agent contributes the most to greenhouse effect?	183	Nitrous oxide	Halothane	Isoflurane	Desflurane	Sevoflurane	<0.01
		135 (73.4%)*	12 (6.5%)		34 (18.5%)	2 (1.1%)	
General anesthetic technique that can minimize greenhouse effect...	183	TIVA	Low flows	Scavenging	Use of air	Use of xenon	<0.01
		145 (78.8%)*	38 (20.65%)	11 (5.97%)	9 (4.89%)	2 (1.08%)	
How often do you use TIVA?	184	Always	Frequently	Occasionally	Rarely	Never	<0.01
		2 (1%)	40 (21.7%)	92 (50%)*	46 (25%)	4 (2.2%)	

halons (halothane, enflurane, isoflurane, desflurane, and sevoflurane) has been discussed for many years,<sup>[6]</sup> but has become obvious since 1985 after the discovery of ozone hole in Antarctica.<sup>[7]</sup> The medical consumption of CFC corresponds to approximately 1% of the total CFC consumption and is mainly used as propellant in pulmonary medicine.<sup>[8]</sup> A widely used anesthetic, N<sub>2</sub>O, is an established GHG and an important ozone-depleting gas.<sup>[2-4]</sup> While 98.4% of the respondents were aware of the greenhouse effect, only 15.8% of the anesthesiologists could identify all the GHG. However, amongst the gases which concern us, 40 (21.7%) respondents could identify only N<sub>2</sub>O, 27 (14.7%) only inhalational agents, and 87 (47.28%) could identify both as a cause of greenhouse effect.

N<sub>2</sub>O remains in the atmosphere for around 150 years,<sup>[9]</sup> and atmospheric lifetimes range between 1.4 and 21.4 years for sevoflurane and desflurane, respectively.<sup>[10,11]</sup> Emissions of gases is conventionally placed on a CO<sub>2</sub>-equivalent scale, the chosen metric being the GWP.<sup>[12]</sup> Thus, GWP is a measure of how much a given mass of greenhouse gas contributes to global warming over a specified time period.<sup>[13]</sup> N<sub>2</sub>O, as a carrier gas for other halogenated agents or as a supplemental anesthetic with intravenous drugs, contributes to around 0.1% of the climate effect,<sup>[14]</sup> whereas halogenated compounds (isoflurane, desflurane, and sevoflurane) contribute to only 0.02%.<sup>[15]</sup> Thus, the main concern should be the use of N<sub>2</sub>O since it is much more widely used than desflurane and in higher quantities. In fact, 1% of the human production of N<sub>2</sub>O is due to its use in clinical anesthesia.<sup>[3]</sup> It is used by 92.9% of the respondents routinely. Thirty-two percent of the respondents would, however, not prefer to use air even if it was made available to them. Twelve percent of the respondents were not comfortable, whereas 20.1% felt that requirement of opioids would increase and thus they continue using N<sub>2</sub>O.

If we consider the GWP of these gases over a 20-year (GWP<sub>20</sub>) and 100-year (GWP<sub>100</sub>) period, we find that GWP of N<sub>2</sub>O is 289 and 298, respectively.<sup>[16]</sup> Desflurane with a lifetime of 10 years<sup>[17]</sup> has a GWP<sub>20</sub> of 3714, as compared to 1980 of sevoflurane and 1401 of isoflurane.<sup>[16]</sup> Despite desflurane being more of a threat to the atmosphere, only 18.5% anesthesiologists recognized it.

Eighty percent of the halogenated anesthetic agents are eliminated through exhalation without being metabolized in the body. Most commonly used anesthesia systems discharge these expired gases directly to the atmosphere, thus polluting the operating suites, and contribute to greenhouse effect due to their longevity. Scavenging systems reduce the spillage in the operating rooms, but

eventually the gases are exhausted into the atmosphere.<sup>[18]</sup> Only 32.1% of the respondents had access to scavenging systems. The consumption of inhaled anesthetics can be reduced by 80-90% if closed circuits are used, especially if “low flow” anesthesia is used along with them. Approximately 92% of the anesthesiologists in our survey use closed circuits and low flows frequently. However, only 72.9% used flows of <2 l/min. The flows assume importance since a higher flow implies a higher concentration in the atmosphere.<sup>[15]</sup>

The alternatives to minimize the greenhouse effect of inhaled anesthetics include use of TIVA as advocated by 78.8%, low flows (20.6%), scavenging (6%), air (4.9%), and xenon (1%). While TIVA precludes the use of all inhaled anesthetics, including N<sub>2</sub>O, using low flows will minimize the consumption of inhalational anesthetics. This, however, is not without environmental costs. Exclusive use of TIVA will require use of plastic syringes and tubings which increase mounds of slow degradable/non-degradable plastic waste. Although 72% of the respondents use TIVA occasionally, only 37.5% of the respondents have access to air. This implies that either they use 100% oxygen or TIVA has been misinterpreted to exclude only the halogen anesthetics. Scavenging, as suggested by 6%, may reduce operating room pollution, but ultimately the gases are released in the atmosphere unless an anesthetic-conserving device utilizing the principle of zeolite filter is incorporated in the anesthesia systems.<sup>[19-21]</sup> The total amount of anesthetics released in the atmosphere can thus be reduced by 40-75%.<sup>[16]</sup> Xenon, an inert gas naturally present in the atmosphere, is devoid of greenhouse effect, but the energy and cost required for its production will mitigate its clinical use.<sup>[16]</sup>

More than the environmental pollution, it is the staff working inside the operating rooms that is more at risk of exposure to the deleterious effects of inhalational agents. Most common example is extreme somnolence with the use of halothane with high flows, which can lead to wavering alertness and increased susceptibility to accidents both inside and outside the operating rooms.

The main limitation of our survey was a low response rate. The anesthesiologists who responded seem to be motivated and show an inclination toward the global aspect of the speciality, willing to embrace newer trends and technologies. Unfortunately, the percentage of such people was not very high. Therefore, the results cannot be generalized to the entire fraternity.

To conclude, while the practising anesthesiologists who participated in the survey were not fully aware of the

greenhouse effect and its implications, their clinical practice inadvertently is such that it minimizes the environmental pollution due to anesthesia. Better resources should be made available to further improve the fraternity's contribution to a clean and safe environment.

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**How to cite this article:** Kumar N, Singh R, Jain A, Bhattacharya A. How green is my operation theater?. *Saudi J Anaesth* 2014;8:493-7.  
**Source of Support:** Nil, **Conflict of Interest:** None declared.