South Afr J Anaesth Analg. 2024;30(5):158-163
https://doi.org/10.36303/SAJAA.3144

South Afr J Anaesth Analg
ISSN 2220-1181 EISSN 2220-1173

ORIGINAL RESEARCH

Anaesthetists' knowledge and practice of environmentally sustainable anaesthesia in an academic department of anaesthesiology

AP Giuricich, T Jeggo, T Kleyenstuber

Department of Anaesthesiology, School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand, South Africa
Corresponding author, email: *agiuricich101@gmail.com*

Background: Climate change is one of the leading threats to humanity today, and the practice of anaesthesia has an appreciable impact on it. This study aims to determine the knowledge regarding environmentally sustainable anaesthesia and the current practices of anaesthetists working in the Department of Anaesthesiology at the University of the Witwatersrand.

Methods: A prospective, descriptive research design was followed. The study population consisted of all anaesthetists working in the Department of Anaesthesiology at the University of the Witwatersrand. A convenience sampling method was used. Data was collected through an online, self-administered questionnaire.

Results: There were 141 responses to the distributed questionnaire. Adequate knowledge of environmentally sustainable anaesthesia was found in 14.90% of participants. There was no significant association between adequate knowledge and age, professional designation, or years of experience ($p = 0.949$). The detrimental effect of inhalational anaesthetic gases (IAG) on the environment was widely known; however, only 15.60% of participants were aware of the risk of propofol to marine life, and 81.56% thought that reusable equipment poses an infection risk. Fresh gas flows (FGF) were not calculated by 66.67% of participants, and their respective knowledge of them was low. Anaesthetic practices were environmentally unsustainable since they were not in keeping with the World Federation Societies of Anaesthesiologists (WFSA), the American Society of Anesthesiologists (ASA), or the South African Society of Anaesthesiologists (SASA) guidelines.

Conclusion: The knowledge of environmentally sustainable anaesthetic practices was low among all anaesthetists at the University of the Witwatersrand; however, there was fair knowledge of the environmental impact of IAGs. Anaesthetic practices were generally environmentally unsustainable, possibly due to the low level of knowledge. Financial constraints and resource limitations need to be considered when analysing practices. Anaesthetists need further training in environmentally sustainable anaesthesia to limit the impact of climate change, given the world's present predicament.

Keywords: knowledge, practices, anaesthesia, greenhouse gases, environment

Introduction

Climate change is one of the leading threats to humanity's long-term sustainability.[1] Although not often considered a significant contributor to emissions, the healthcare sector is one of the largest producers of greenhouse gas (GHG) emissions, one of the leading drivers of climate change.[1] Anaesthesia, through its use of inhalational anaesthetic gases (IAGs), intravenous agents, disposable equipment, consumables, and cleaning and sterilisation of reusable equipment, contributes heavily to the impact of the overall healthcare sector on the environment.[1,2]

Professional anaesthesiology societies are aware of the field's environmental impact and have taken a stance on the issue: the World Federation Societies of Anaesthesiologists (WFSA) has created a global consensus statement on the principles of environmentally sustainable anaesthesia practices.[3] The American Society of Anesthesiologists (ASA) has guidelines on environmentally sustainable anaesthetic practices.[4] In South Africa, SASA has recently developed a position statement on the environmental impact of IAGs and has guidelines on making anaesthesia more environmentally sustainable.[5]

There is increasing global recognition of the healthcare system's impact on climate change and the contributions of anaesthesia. Studies on anaesthetists' knowledge of environmentally sustainable anaesthesia have been performed in developed countries. However, discussions about these topics are still in their infancy within the South African medical community. There has been limited research on environmentally sustainable anaesthesia performed in South Africa. More research is required to assess the understanding that South African anaesthetists have of climate change and their field's impact on the environment.

The study aims to determine the knowledge and practices of environmentally sustainable anaesthesia. Assessing knowledge will assist in assessing the need for more teaching during training. Evaluating anaesthetists' practices will bring to light the extent of current environmentally sustainable practices and assess the need to change current practices. This can assist in developing guidelines and policies regarding environmentally sustainable practices in South Africa. Overall, training anaesthetists to practice in an environmentally sustainable manner is important to limit climate change.

Methods

Approval was obtained from the Human Research Ethics Committee (Medical-M230717) and other relevant authorities. A prospective, descriptive research design was followed.

The study population consisted of all anaesthetists working in the Department of Anaesthesiology at the University of the Witwatersrand in October 2023. A convenience sampling method was used. Questionnaires were distributed to the entire accessible population. Based on best practice guidelines, a 60% response rate was calculated. Therefore, a minimum of 137 responses was required from the 228 eligible participants.[6]

A questionnaire was developed following a review of the international literature and internationally validated guidelines, namely the WFSA and ASA guidelines.[3,4] Since there is no validated South African questionnaire on this matter, contextual fit had to be obtained. This was done by reviewing the validated questionnaire used by Muller at the University of the Witwatersrand.[7] The draft questionnaire was reviewed by three senior anaesthetists to ensure face and content validity. Their comments were incorporated into the final questionnaire. The questionnaire consists of three sections:

- Part 1: demographics.
- Part 2: knowledge. This section includes questions on the impact of IAGs, the types and uses of flows, the impact of intravenous medications, and equipment life cycle assessments (LCA).
- Part 3: practices. This section includes questions on practices regarding the types of IAG used, the types of flows used, routine drug use, the disposal of propofol, and preferences for using sterilised equipment.

The modified Angoff method was used to determine the pass mark for the knowledge section in the questionnaire.[8,9] Senior consultants in anaesthesia, who have a special interest in green anaesthesia, assisted in setting the pass mark.[8,9]

The questionnaire was developed into an electronic version using REDCap®. A link to the information letter and questionnaire was sent out via email and on departmental WhatsApp® groups during daytime hours. Once completed, data was automatically collected electronically. Microsoft® Excel was used for data capturing. A biostatistician was consulted to assist with data analysis, and the statistical program STATA® version 17 (StataCorp, USA) was used. Categorical variables were described using frequencies and percentages. The distribution of the data was determined. The normally distributed continuous data was described using means and standard deviations. Skewed data was analysed using medians and interquartile ranges. A *p*-value of 0.05 or less was considered statistically significant.

Results

The questionnaire was distributed to all medical officers, registrars, and consultants employed in the department as of October 2023 ($n = 222$). The total number of responses was 141, representing a response rate of 63.51%.

Missing data

Of the 141 questionnaires, not all the questions were answered, and this missing information was random in the dataset. To analyse all the data using a sample size of 141, a "no response" category was created for each variable with incomplete responses. The data analysis for the "no response" was reported as number (*n*) and percentage (%) for each variable and analysed independently.

Demographic characteristics

The median age of the participants was 33 years. Table I shows their demographics. Most participants were consultants (56.03%, $n = 79$), followed by registrars (22.70%, $n = 32$). Most participants had worked for 5–10 years (39.72%, $n = 56$) and 11–20 years (42.55%, $n = 60$).

Knowledge of participants

Table II shows the responses to the knowledge questions. The Global Warming Potential 100 (GWP_{100}) is known as the heat absorbed by any GHG in the atmosphere, as a multiple of the heat that the same mass of CO_2 (carbon dioxide) would absorb, and by convention, is 100 years; which is the atmospheric lifetime of CO_2.[3,4] This was known by 60.99% ($n = 86$) of the participants and 48.23% ($n = 68$) correctly indicated that desflurane has the greatest GWP_{100}. A FGF of 4 L/min, considered high-flow anaesthesia, was correctly selected by only 10.64% ($n = 15$) of participants. Likewise, only 14.18% ($n = 20$) correctly chose low-flow anaesthesia, a FGF value of less than 2 L/min. Most participants correctly indicated that a low FGF (95.04%, $n = 134$) is the more environmentally friendly option. Only 17.70% ($n = 25$) knew that intravenous techniques, such as total intravenous anaesthesia (TIVA), are more environmentally friendly than inhalational anaesthesia, whereas most of the participants (68.1%, $n = 96$) were unsure. Only 15.60% ($n = 22$) of participants considered propofol or its metabolites to be a high risk to aquatic life; however, the correct disposal of propofol was selected by 46.80% ($n = 66$) (a sharps bin) and 48.90% ($n = 69$) (red bags).

The correct definition of LCA is the environmental emissions of products, including raw material extraction, refining, manufacturing, packaging, transportation, clinical use, reuse, and maintenance and waste management strategies.[3,4] The correct definition of LCA of a reusable laryngeal mask airway (LMA) was selected by 48.20% ($n = 68$), and 58.16% ($n = 82$) of participants considered reusable equipment more environmentally friendly than disposable equipment. However, the equipment with the greatest environmental impact depends on multiple factors.

Table I: Demographic characteristics of participants

Variable	Categories	Number (*n*)	Percentage (%)
Professional designation	No response	6	4.25
	Medical officer	24	17.02
	Registrar	32	22.70
	Consultant	79	56.03
Years of experience	No response	5	3.55
	< 5	13	9.22
	5–10	56	39.72
	11–20	60	42.55
	> 20	7	4.96

Table II: Responses to knowledge questions relating to environmentally friendly anaesthesia

Questions	Responses	Number (*n*)	Percentage (%)
Do you know what the "Global Warming Potential 100 (GWP_{100})" stands for?	No response	5	3.55
	Yes	86	60.99
	No	50	35.46
Which gas has the greatest GWP_{100}?	No response	5	3.55
	Desflurane	68	48.23
	Halothane	2	1.42
	N_20	19	13.47
	Sevoflurane	4	2.84
	Unsure	43	30.49
Above which FGF is considered to be high-flow anaesthesia?	No response	5	3.55
	1	29	20.57
	2	71	50.35
	3	12	8.51
	4	15	10.64
	5–8	9	6.38
Below which FGF is considered to be low-flow anaesthesia?	No response	6	4.26
	0.5	18	12.77
	1	88	62.41
	1.5	8	5.67
	2	20	14.18
	2.5	1	0.71
Which FGF is more environmentally friendly?	No response	5	3.55
	Low-flow	134	95.03
	High-flow	1	0.71
	Unsure	1	0.71
The risk of propofol or its metabolites to aquatic life is?	No response	6	4.26
	Low	59	41.84
	High	22	15.60
	Unsure	54	38.30
How should unused drawn-up propofol be discarded?	No response	5	3.55
	Sharps bin	66	46.81
	Red bag	69	48.94
	General waste	2	1.42
	Municipal drain	1	0.71
	Unsure	11	7.80
A life cycle assessment of reusable laryngeal mask airways evaluates?	No response	5	3.55
	Option A*	68	48.23
	Option B**	7	4.96
	Option C***	61	43.26
Considering reusable or disposable anaesthetic equipment, which of the two has a greater environmental impact?	No response	5	3.55
	Reusable	82	58.16
	Disposable	45	31.91
	It depends	9	6.38

* Option A: The environmental impact associated with the natural resource extraction, manufacturing, packaging, transport, use/reuse, and recycling/waste disposal of LMAs.
** Option B: The total number of times that a reusable LMA can be safely used before it should be disposed of.
*** Option C: The environmental impact before a new reusable LMA is marketed and released.

Reusing equipment after sterilisation poses no infection risk to patients, which was correctly selected by only 14.89% (*n* = 21).

Knowledge score

N_2O (nitrous oxide) gas, which has the longest atmospheric lifetime, was correctly selected by 32.62% (*n* = 42) of participants. Desflurane, which traps the most radiation, was correctly selected by 40.43% (*n* = 50) of participants. The full complement of responses is shown in Figure 1.

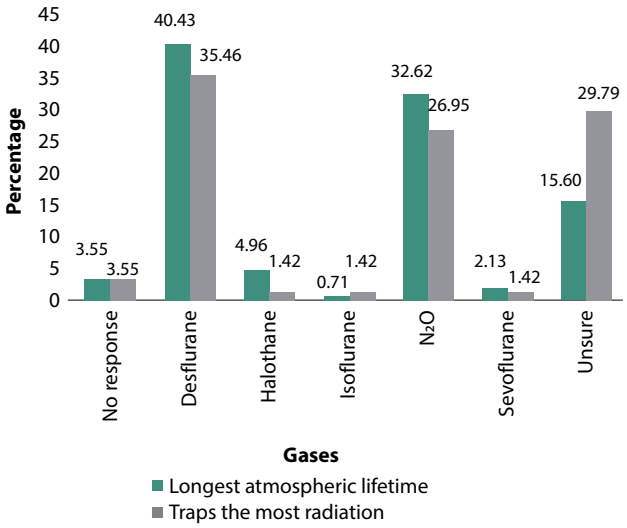

Figure 1: Participants' knowledge of which gas has the longest atmospheric lifetime and traps the most radiation

Figure 2 shows the scores for the knowledge assessment of the participants. The modified Angoff pass mark was set at 62.85%. There were 13 questions, each of which were scored. Overall, the participants' scores ranged from 0 to 12 out of 13. Of the participants, 53.91% (*n* = 76) scored 6 or less out of 13. Using the modified Angoff pass mark, participants needed to score 9 or more out of 13 to pass. The percentage of participants who passed and had adequate knowledge was 14.89% (*n* = 21), indicated by the green bars in Figure 2.

Among the consultants, 17.70% had adequate knowledge, while 9.38% of the registrars had adequate knowledge. There was no significant association between adequate knowledge and age, professional designation, or years of experience ($p = 0.949$).

Practices

Table III displays the participants' current anaesthetic practices. Sevoflurane (94.33%, *n* = 113) is the most used inhalational anaesthetic agent. N_2O is available to 54.60% (*n* = 77) of the participants. Of those who indicated that N_2O gas was available, only 10.39% (*n* = 8) confirmed that they checked the piping for cracks. Regarding desflurane, 73.05% (*n* = 103) of participants indicated that they use it once monthly. An open system was used once a week by 51.06% (*n* = 72) of participants, and 66.67% (*n* = 94) calculated the FGF. The FGF was always changed by 68.8% (*n* = 97) of participants during the maintenance phase of anaesthesia, and 44.6% (*n* = 63) checked the breathing system for leaks. Both the FGF and vapouriser are paused by 14.89% (*n* = 21) whilst instrumenting the airway, which is the advocated method.

Most anaesthetists (80.14%, *n* = 113) indicated that they implemented strategies to lower the minimum alveolar concentration (MAC), and the use of intravenous opioids was the most common method. More than half of anaesthetists routinely draw up emergency drugs, and phenylephrine was the most commonly drawn-up emergency drug (34.75%, *n* = 49). Only 8.50% (*n* = 12) of participants indicated that

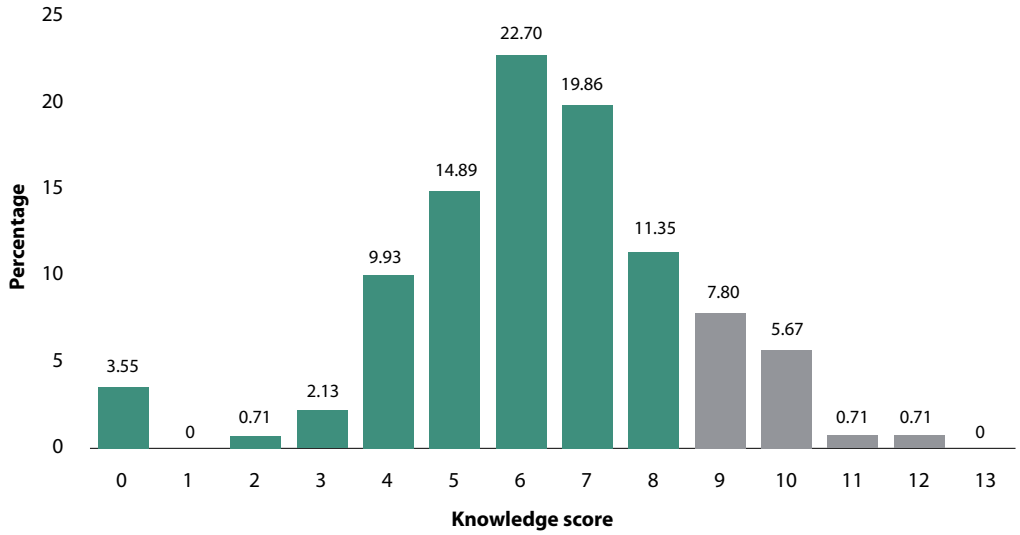

Figure 2: Knowledge scores (< 9 = inadequate knowledge, ≥ 9 = adequate knowledge)

Table III: Anaesthetic practices of the participant

Question	Response	Number (*n*)	Percentage (%)
Which inhalation anaesthetic agent do you most commonly use in your daily practice?	No response	5	3.55
	Desflurane	1	0.71
	Isoflurane	2	1.42
	Sevoflurane	133	94.32
Is N_2O available where you work?	No response	5	3.55
	No	59	41.84
	Yes	77	54.61
How often do you use desflurane?	No response	5	3.55
	Never	103	73.05
	1 × month	24	17.02
	2 × month	1	0.71
	3 × month	3	2.13
	More than 3 × month	4	2.83
	Everyday	1	0.71
How often do you use open systems (such as the Jackson-Rees or Ayre's T-piece)?	No response	5	3.55
	Never	17	12.06
	1 × month	72	51.06
	2 × month	31	21.99
	3 × month	8	5.67
	More than 3 × month	8	5.67
	Everyday	0	0
Do you calculate the appropriate fresh gas flow rate when conducting inhalational inductions?	No response	5	3.55
	Never	94	66.66
	1 × month	16	11.35
	2 × month	13	9.22
	3 × month	3	2.13
	More than 3 × month	10	7.09
	Everyday	0	0
Which do you pause whilst instrumenting the airway?	Fresh gas flow	13	9.22
	Vapouriser	31	21.99
	Both	21	14.89
	None	71	50.35
	No response	5	3.55
Do you implement strategies to use a lower MAC during the maintenance phase of anaesthesia?	No response	5	3.55
	No	23	16.31
	Yes	113	80.14
Do you routinely draw up emergency drugs?	No response	5	3.55
	Yes	79	56.03
	No	57	40.42
Which emergency drugs do you routinely use?	Adrenaline (1 : 100)	37	26.24
	Adrenaline (1 : 10)	32	22.70
	Atropine	7	4.96
	Ephedrine	6	4.96
	Phenylephrine	49	34.75
	Suxamethonium	6	4.26
Do you choose to do regional blocks instead of general anaesthesia, if clinically applicable?	No response	6	4.26
	Yes	12	8.51
	No	123	87.23
Where do you dispose of unused propofol?	No response	5	3.55
	Sharps bin	77	54.61
	Red bag	72	51.06
	General waste	4	2.84
	Municipal drain	1	0.71
	Unsure	11	7.88
Do you reuse (after appropriate cleaning) any of the following equipment?	Masks	130	92.20
	Venturi face masks	8	5.67
	Rebreather masks	4	2.84
	Nasal prongs	2	1.42
	Laryngoscope blade	126	89.36
	Laryngeal mask airway	42	29.79
	Other	8	5.67

they use regional blocks instead of general anaesthesia, when clinically applicable, which is the more environmentally friendly practice. Unused, opened propofol is correctly disposed of in both the sharps bin and red bin by 54.61% (*n* = 77) and 48.94% (*n* = 69) of participants, respectively. The most reused equipment were masks (92.20%, *n* = 130) and laryngoscope blades (89.36%, *n* = 126). The least reused equipment was nasal prongs (1.42%, *n* = 2).

Discussion

This study sheds light on the current knowledge and practices of environmentally sustainable anaesthesia in the Department

of Anaesthesia at the University of the Witwatersrand. Internationally, the ASA and WFSA have put forward guidelines, and SASA has developed a position statement on the environmental impact of IAGs.

In this study, the overall knowledge of environmentally friendly anaesthesia was poor. Only 14.90% (n = 21) of participants achieved an adequate knowledge score. There was no significant association between adequate knowledge and age, professional designation, or years of experience (p = 0.949), highlighting a lack of knowledge throughout the department. In comparison, a study of South African anaesthetists by Frewen et al. reported that 35% of respondents felt they had appropriate knowledge. However, no testing of this knowledge was done.[10] Frewen et al. also found enthusiasm among anaesthetists to adopt more environmentally friendly practices.[10]

There are international studies on the knowledge of the environmental impact of IAGs. In Switzerland, Gasciauskaite et al. found that 43.50% of anaesthetists knew that IAGs cause ecological damage.[11] In this study, 60.99% of respondents knew what the GWP_{100} stands for, showing that anaesthetists at the University of the Witwatersrand are aware of the environmental impact of IAGs. In Canada, Zaw et al. found that anaesthetists believed sevoflurane was the more environmentally friendly IAG.[12] Ard et al. found that among American anaesthetists, sevoflurane was the most used IAG (66.40%).[13] Comparably, this study found that participants knew that sevoflurane was not the IAG with the greatest GWP_{100}, and 94.33% (n = 133) commonly used sevoflurane. Although the knowledge of the detrimental effects of IAGs is high, the practices of how IAGs are used are environmentally unsustainable.

Only 14.18% and 10.64% of participants knew the correct low and high FGF value cut-off, respectively. However, Kapajika et al. found that 56.30% of anaesthetists at the University of the Witwatersrand had a fair knowledge of low-flow anaesthesia.[14] This discrepancy needs further investigation since both studies were undertaken in the same department, albeit at different times. The ASA and WFSA state that low-flow anaesthesia is more environmentally sustainable, and most participants (95.04%) chose low-flow anaesthesia.[3,4] This contrasts with Gasciauskaite et al., who found that 46.80% of anaesthetists knew to minimise FGF to make anaesthesia more environmentally sustainable.[11]

The appropriate FGF was not calculated by 66.67% of respondents. Again, this contradicts Kapajika et al.'s findings on low-flow anaesthesia in the same department.[14] Only 21.99% of respondents paused the FGF whilst instrumenting the airway. According to ASA guidelines, turning off the FGF, not the vapouriser, during intubation is recommended.[4] A lack of education could explain these practices. Although N_2O was available to 77% of respondents, N_2O should not be used in Gauteng. Due to the altitude, the atmospheric pressure is too low, and according to Henry's Law, a therapeutic partial pressure in blood is thus not achievable.[15] Furthermore, most did not check the N_2O piping for cracks. Internationally, 80% of the total anaesthetic gas environmental footprint from 2019 to 2020 was due to N_2O.[15]

The environmental impact and usage of desflurane in this study's setting can be said to be minimal. Only one participant said they primarily use desflurane in their daily practice. By comparison, desflurane use in America is much more common (22.3%).[16] From January 2026, the European Union has devised a proposal to ban or restrict the use of desflurane.[16] In South Africa, the lack of desflurane use in the public sector is not due to environmental considerations but could instead be caused by a resource constraint.[17]

Of the respondents, 68.09% were unsure if TIVA techniques were better for the environment. Regarding propofol, 41.84% said that the risk of propofol to aquatic life is low, 15.60% said it was high, and 38.30% were unsure. In contrast, Gasciauskaite et al. found that 43.50% of anaesthetists knew propofol could cause ecological damage.[11] Propofol is considered hazardous to marine life due to in vitro environmental risk experiments using high concentrations of propofol, which is the "worst-case scenario".[18] However, new evidence has shown a low risk to marine life at the concentrations at which propofol is found in water bodies. The concern for the environment occurs when there is increased incorrect disposal of propofol, commonly from TIVA.[18,19]

The correct disposal of propofol was widely known, as 66 participants said the sharps bin and 69 participants said the red bag. Both are correct, as propofol needs to be incinerated, and both the sharps bin and red bag are disposed of in that manner.[18,20]

Less than half (48.23%) of respondents knew what a LCA was, which can explain why only 6.38% of respondents correctly knew whether reusable or disposable equipment had a better environmental impact. The source of electricity used for producing and reprocessing reusable and disposable equipment contributes to their environmental impact.[21] Gasciauskaite et al. found that only 12.9% of anaesthetists identified reusing equipment as a critical measure to make anaesthesia more sustainable.[11] Frewen et al. found that South African anaesthetists frequently reuse equipment and are eager for more reuse.[10] The study's most reused equipment were masks (92.20%) and laryngoscope blades (89.36%). Again, this is likely due to financial constraints rather than environmental awareness. Internationally, there is a move towards reusing even more types of equipment, and this should be adopted in South Africa.[2,21]

In contrast to the study by Frewen et al., who found that only 13.6% of anaesthetists think reusing equipment poses an infection risk, this study found that 81.56% of respondents think reusing equipment poses an infection risk.[10] Reusing equipment has not been found to pose an increased risk of infection. However, the large discrepancy between the perceived risk of infection and the practice of reusing equipment in this study is contradictory.

Emergency drugs are routinely drawn up by 56% of respondents. However, Stone et al. found that 87% of obstetric anaesthetists in the United Kingdom routinely draw up emergency drugs, and Majeed et al. stated that drawing up emergency drugs is common practice in anaesthesia.[22,23] In the South African public health setting, the lack of routine drawing up of emergency drugs can be due to resource constraints. Phenylephrine is the most commonly drawn-up emergency drug (34.75%), correlating with the findings from Majeed et al.[23]

The study found that regional blocks are not commonly performed instead of general anaesthesia. This may be explained by resource constraints, a possible lack of skill to perform the blocks, and a lack of knowledge of the environmental effects of general anaesthesia. Although regional anaesthesia is more environmentally sustainable, Kuvadia et al.[24] showed that it also has cost-saving benefits.

Closed circuits are the most common anaesthetic circuit used and clinically relevant circuits used in first-world countries.[25,26] Open systems were used by 51.06% of respondents once a week, and this is usually the Jackson-Rees circuits, commonly used in inhalational induction in paediatric cases.[26] Open systems, like the Jackson-Rees, readily release excess IAG into the atmosphere.[27] Gray and Jacobs, from Cape Town, found that using a low-flow induction method during inhalation induction with sevoflurane would save around 43 110 ml of sevoflurane and R155 000 annually.[28] This method can also be viewed as more environmentally sustainable.

This study has certain limitations. The study was undertaken contextually in the Department of Anaesthesiology at the University of the Witwatersrand, and the results may not be generalisable. Anaesthetists' knowledge does not always reflect their actual practice. Different facility-based equipment and practices at the hospitals affiliated with the University of the Witwatersrand may also impact environmentally sustainable practices.

Conclusion

All anaesthetists had low knowledge of environmentally sustainable anaesthetic practices; however, they had a fair knowledge of the environmental impact of IAGs. Anaesthetic practices were generally environmentally unsustainable, which can be ascribed to the low level of knowledge. Financial and resource constraints must be considered when analysing practices. Anaesthetists at the University of the Witwatersrand need further training in environmentally sustainable anaesthesia to limit the impact of climate change.

Acknowledgements

This research was done in partial fulfilment of a Master of Medicine degree.

Conflict of interest

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this paper.

Ethical approval

Ethical approval was obtained from the University of the Witwatersrand Human Research Ethics Committee (M230717).

ORCID

AP Giuricich https://orcid.org/0009-0000-0093-4784
T Jeggo https://orcid.org/0009-0009-2207-1903
T Kleyenstuber https://orcid.org/0000-0001-5219-3869

References

1. Weller M. A general review of the environmental impact of health care, hospitals, operating rooms, and anesthetic care. Int Anesthesiol Clin. 2020;58(4):64-9. https://doi.org/10.1097/AIA.0000000000000295.
2. Reynier T, Berahou M, Albaladejo P, Beloeil H. Moving towards green anaesthesia: are patient safety and environmentally friendly practices compatible? A focus on single-use devices. Anaesth Crit Care Pain Med. 2021;40(4):100907. https://doi.org/10.1016/j.accpm.2021.100907.
3. White SM, Shelton CL, Gelb AW, et al. Principles of environmentally-sustainable anaesthesia: a global consensus statement from the World Federation of Societies of Anaesthesiologists. Anaesthesia. 2022;77(2):201-12. https://doi.org/10.1111/anae.15598.
4. Axelrod D, Bell C, Feldman J, et al. Greening the operating room (OR) and perioperative arena: environmental sustainability for anesthesia practice [Internet]. 2nd ed. American Society of Anesthesiologists; 2014. p. 1-3. Available from: https://www.asahq.org/about-asa/governance-and-committees/asa-committees/environmental-sustainability/greening-the-operating-room. Accessed 29 March 2023.
5. South African Society of Anaesthesiologists (SASA). SASA position statement 2024: environmental impact of inhalation anaesthetics. SASA; 2024. p. 2-4.
6. Draugalis JR, Plaza CM. Best practices for survey research reports revisited: implications of target population, probability sampling, and response rate. Am J Pharm Educ. 2009;73(8):142. https://doi.org/10.5688/aj7308142.
7. Muller E. Knowledge and practices of anaesthetists regarding the disposal of waste anaesthetic gases and sharps in a department of anaesthesiology. Johannesburg: University of the Witswatersrand; 2020.
8. Wheaton A, Parry J. Using the Angoff method to set cut scores [Internet]. New Orleans; 2012. Available from: https://www.pmcommunity.ro/download/examen_pmp/Metoda%20Angoff%20scoring%20examen%20PMP%20-%20detalii.pdf. Accessed 23 May 2019.
9. Shulruf B, Wilkinson T, Weller J, Jones P, Poole P. Insights into the Angoff method: results from a simulation study. BMC Med Educ. 2016;16(134). https://doi.org/10.1186/s12909-016-0656-7.
10. Frewen L, Grossman ES, Basson C. Mostly harmless? A survey of South African anaesthetists' knowledge and attitudes regarding environmental sustainability in the operating theatre. South Afr J Anaesth Analg. 2022;28(1):35-40. https://doi.org/10.36303/SAJAA.2022.28.1.2658.
11. Gasciauskaite G, Lunkiewicz J, Spahn DR, et al. Environmental sustainability from anesthesia providers' perspective: a qualitative study. BMC Anesthesiol. 2023;23(377). https://doi.org/10.1186/s12871-023-02344-1.
12. Zaw MWW, Leong KM, Xin X, et al. The perceptions and adoption of environmentally sustainable practices among anesthesiologists-a qualitative study. Can J Anaesth. 2023;70(3):313-26. https://doi.org/10.1007/s12630-022-02392-0.
13. Ard Jr JL, Tobin K, Huncke T, et al. A survey of the American Society of Anesthesiologists regarding environmental attitudes, knowledge, and organization. A A Case Rep. 2016;6(7):208-16. https://doi.org/10.1213/XAA.0000000000000184.
14. Kapajika DB. The practice and knowledge of low flow anaesthesia in a department of anaesthesiology [Internet]. Johannesburg: University of the Witwatersrand; 2021. Available from: https://wiredspace.wits.ac.za/server/api/core/bitstreams/b463edf4-249a-4e5d-bb9e-94f02069ff79/content. Accessed 4 January 2024.
15. anaesthetists.org [Internet]. Nitrous oxide project. Association of Anaesthetists. Available from: https://anaesthetists.org/Home/Resources-publications/Environment/Nitrous-oxide-project. Accessed 5 December 2023.
16. Hendrickx JFA, Nielsen OJ, De Hert S, De Wolf AM. The science behind banning desflurane: a narrative review. Eur J Anaesthesiol. 2022;39(10):818-24. https://doi.org/10.1097/EJA.0000000000001739.
17. Maphumulo WT, Bhengu BR. Challenges of quality improvement in the healthcare of South Africa post-apartheid: a critical review. Curationis. 2019;42(1):1901. https://doi.org/10.4102/curationis.v42i1.1901.
18. Waspe J, Orr T. Environmental risk assessment of propofol in wastewater: a narrative review of regulatory guidelines. Anaesthesia. 2023;78(3):337-42. https://doi.org/10.1111/anae.15967.
19. Kostrubiak M, Vatovec CM, Dupigny-Giroux L-A, et al. Water pollution and environmental concerns in anesthesiology. J Med Syst. 2020;44(9):169. https://doi.org/10.1007/s10916-020-01634-2.

20. Lane SF. The environmental sustainability of propofol use in daily practice. Br J Anaesth. 2020;124(6):e221-2. https://doi.org/10.1016/j.bja.2020.03.009.
21. McGain F, Ma SC, Burrell RH, et al. Why be sustainable? The Australian and New Zealand College of Anaesthetists Professional Document PS64: statement on environmental sustainability in anaesthesia and pain medicine practice and its accompanying background paper. Anaesth Intensive Care. 2019;47(5):413-22. https://doi.org/10.1177/0310057X19884075.
22. Stone JP, Fenner LB, Christmas TR. The preparation and storage of anaesthetic drugs for obstetric emergencies: a survey of UK practice. Int J Obstet Anesth. 2009;18(3):242-8. https://doi.org/10.1016/j.ijoa.2009.01.013.
23. Majeed A, Firdous A, AlBabtain H, Iqbal T. Cost drain of anesthesia emergency drugs in a quaternary care hospital. Saudi J Anaesth. 2019;13(3):203-7. https://doi.org/10.4103/sja.SJA_706_18.
24. Kuvadia M, Cummis CE, Liguori G, Wu CL. 'Green-gional' anesthesia: the non-polluting benefits of regional anesthesia to decrease greenhouse gases and attenuate climate change. Reg Anesth Pain Med. 2020;45(9):744-5. https://doi.org/10.1136/rapm-2020-101452.
25. Garrett A, Stahl DL. Anesthesia breathing systems [Internet]. Treasure Island: StatPearls Publishing; 2023 [updated 2023 January 29]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK574503/. Accessed 12 September 2023.
26. Nel D. Anaesthetic workstation. South Afr J Anaesth Analg. 2023;29(5 Suppl 1):49-53. https://doi.org/10.36303/SAJAA.3027.
27. Sellers C, Woodman N. Inhalational induction in paediatric anaesthesia. BJA Educ. 2023;23(1):32-8. https://doi.org/10.1016/j.bjae.2022.10.002.
28. Jacobs JHLR, Gray R. Low flow inhalation induction: an aid to green anaesthesia. Poster presentation presented at PACSA; 2022. Department of Anaesthesia and Peri-operative Medicine, University of Cape Town.