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ORIGINAL RESEARCH

Sustainability in anaesthesia: are South African anaesthesia providers doing their part?

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Background: The world's reliance on fossil fuels has led to broad environmental ramifications. The most significant is climate change, the acute rise in global temperatures due to greenhouse gas (GHG) emissions. Anaesthetists may be able to reduce the environmental footprint of a hospital and the healthcare system. This study attempted to ascertain the practices of South African anaesthesia providers and compare these practices to international sustainability recommendations.

Methods: Through an analytical, cross-sectional study, members of the South African Society of Anaesthesiologists (SASA) were surveyed. After a literature review, a survey was constructed based on current recommendations and reviewed for face validity. The data was exported to a spreadsheet for statistical analysis. Associations were described using the chi-square or Fisher's exact test for categorical data and the t-test or Kruskal–Wallis test for numerical data.

Results: Volatile anaesthesia without nitrous oxide (N_2O) was reported as the preferred (73.5% first choice) anaesthetic technique. Total intravenous anaesthesia (TIVA) and regional/neuraxial-only anaesthesia were equally selected as the practitioner's second preference. The use of N_2O with volatiles is very unpopular. Sevoflurane was the most preferred volatile agent (79.9% first choice). Isoflurane and desflurane were popular second-choice agents. Anaesthetists comply with some recommendations and neglect others. The use of low fresh gas flows (FGF), reusable laryngoscope blades, TIVA, and regional/neuraxial-only techniques are in keeping with the recommendations. Single-use laryngeal mask airways (LMA), desflurane, and frequent replacement of breathing circuits breach the recommendations. Anaesthetists are willing to incorporate sustainability into their practices but identified lacking education, staff attitudes, and poor leadership as barriers to improvement.

Conclusion: South African anaesthesiologists perform well in certain aspects of sustainability, but not all of them. This is comparable to international literature. The significant differences in practice among subgroups of anaesthetists are unique to the South African context. Overall, the study showed opportunities for improvement throughout the South African anaesthesia fraternity.

Keywords: anaesthesia, anaesthetist, climate change, environment impact, greenhouse gas, global warming, sustainability

Introduction

Climate change is one of the global scientific community's most pressing concerns.[1,2] The prevailing scientific theory states that the leading cause of climate change is global warming through greenhouse gas (GHG) emissions, most of which are derived from human enterprise.[1] Climate change appears to be intensifying, with the highest recorded average yearly global temperatures from November 2022 to October 2023.[3] The repercussions of uncontrolled climate change are far-reaching and destructive.[1,3-5] Curtailing GHG emissions is a priority.

Southern Africa is particularly susceptible to the destructive consequences of climate change.[6] Compared to the rest of the world, temperatures in Southern Africa are climbing faster. Other phenomena, such as droughts and rising sea levels, are more pronounced. Furthermore, communities in the region are more susceptible to the effects of climate change.[7] Compounding the matter are the conflicting objectives of economic development and carbon neutrality. Countries within the region must find a way to balance economic growth and sustainability.[7]

The healthcare industry produces considerable amounts of GHG emissions.[8-10] Within the healthcare sector, hospitals are the largest emitter of GHGs. Furthermore, operating rooms (OR) are hospitals' primary GHG production source. ORs contribute to GHG emissions through medical waste production, anaesthetic vapours, medical gasses, heating, ventilation and air-conditioning (HVAC), and single-use plastic consumption.[8,11]

Of particular interest is the greenhouse effects of volatile anaesthetic agents. Seminal studies have described the environmental impact of these agents by investigating the two main factors that determine the environmental maleficence of an agent.[12-14] These two factors are global warming potential (GWP) and ozone depleting potential (ODP). However, other factors also influence the agent's overall environmental impact. These factors include but are not limited to, synthesis, packaging, transport, storage, and delivery systems of inhalational anaesthetics.[15]

When comparing volatile agents, desflurane is clearly the least sustainable, and sevoflurane is the most sustainable agent. Nitrous oxide (N_2O) is particularly damaging due to its direct effects (high GWP and ODP) and its effect on the rate of volatile anaesthetic consumption (Table I).[15,16] Alternative anaesthetic techniques like propofol-based total intravenous anaesthesia (TIVA) are more sustainable than inhalation techniques but are not benign. The literature describes the biotoxic effects of

propofol on aquatic fauna.[17] Some authors have suggested that the most environmentally friendly technique available is regional/neuraxial-only methods.[18]

Table I: GWP and ODP of volatile agents[13,19]

Agent	GWP	ODP
Halothane	50	1.56
Sevoflurane	130	0.00
N_2O	298	0.02
Isoflurane	510	0.03
Desflurane	2 540	0.00

GWP – global warming potential, N_2O – nitrous oxide, ODP – ozone depleting potential

The anaesthesiologist forms the core of every OR. It follows that the anaesthesiologist can play a central role in managing the environmental impact of the healthcare sector. As a result, guidelines have been established to aid anaesthesiologists in their attempt to improve sustainable OR practices. The recommendations include avoidance of volatile agents with a high GWP like desflurane, utilising low fresh gas flows (FGF) and automated end-tidal control, propofol-based TIVA, regional/neuraxial techniques, waste anaesthetic gas (WAG) trapping devices, weekly breathing circuit replacement, reusable laryngeal mask airways (LMAs) and laryngoscope blades, and prefilled syringes.[18,20-22] Compliance with these recommendations and anaesthetic practices vary among countries.[23-26]

Information regarding South African practices is lacking. Frewen et al.[27] investigated the attitudes and knowledge of anaesthesia providers in South Africa. Their study found that South African anaesthesiologists are inclined to improve sustainability, willing to educate themselves and others regarding sustainable practices, and would like to recycle OR waste. The study identified multiple barriers to implementing these initiatives, including a lack of knowledge, OR personnel behaviour, and the absence of recycling establishments.[27] However, the study did not focus on the actual practices of anaesthesiologists.

This study aimed to build on the work done by Frewen et al.[27] by exploring the practices of South African anaesthesia providers and further investigating attitudes and perceived barriers to improvement.

Methods

Ethical approval was obtained from the University of the Free State (UFS) Health Sciences Research Ethics Committee. An analytical, cross-sectional study utilising an online survey was conducted. The survey was hosted on REDCap via Safe Surgery South Africa (SSSA). The researchers took part in the pilot study to test the functionality of the online survey. After reading the information page, the respondents gave informed consent and continued to fill out the questionnaire. All full and associate members of South African Society of Anaesthesiologists (SASA) received an email request to participate in the study. Repeat requests were sent to improve the response rate. To prevent duplicate responses, members who already completed the survey did not receive a reminder. Data collection took place from January to June 2023.

The questionnaire consisted of four parts. Part one contained relevant demographic questions. Part two collected categorical data about current anaesthetic practices via multiple-choice questions (MCQ). Part three attempted to gauge the respondents' attitudes and opinions regarding sustainability in anaesthesia via MCQs and Likert scale questions. Part four contained one MCQ regarding perceived barriers to sustainability improvement in anaesthesia. Questions were constructed from questionnaires in the literature and current recommendations for limiting the environmental impact of anaesthesia.

The data were exported to an Excel spreadsheet, and the Department of Biostatistics of the UFS performed statistical analysis. Associations were calculated and described using the chi-square or Fisher's exact test for categorical data and the t-test or Kruskal–Wallis test for numerical data.

Table II: Demographic data of respondents

Variable	*n*	Percentage
Age (*n* = 354)		
20–29	11	3.1
30–39	131	37.0
40–49	92	25.9
50–59	55	15.5
≥ 60	65	18.4
Experience in anaesthesia in years (*n* = 354)		
0–5	62	17.5
6–10	84	23.7
11–15	46	12.9
≥ 16	162	45.8
Role (*n* = 353)		
General practitioner	28	7.9
Specialist in training (registrars)	75	21.3
Specialist anaesthesiologist	250	70.8
Province (*n* = 354)		
Gauteng	118	33.3
Western Cape	102	28.8
KwaZulu-Natal	51	14.4
Eastern Cape	19	5.4
Northern Cape	8	2.3
Free State	39	11.0
North-West Province	8	2.3
Mpumalanga	5	1.4
Limpopo	4	1.1
Type of practice (*n* = 354)		
Private practice only	189	53.4
Government practice only	137	38.7
Combined private and government practice	13	3.7
Other	15	4.2

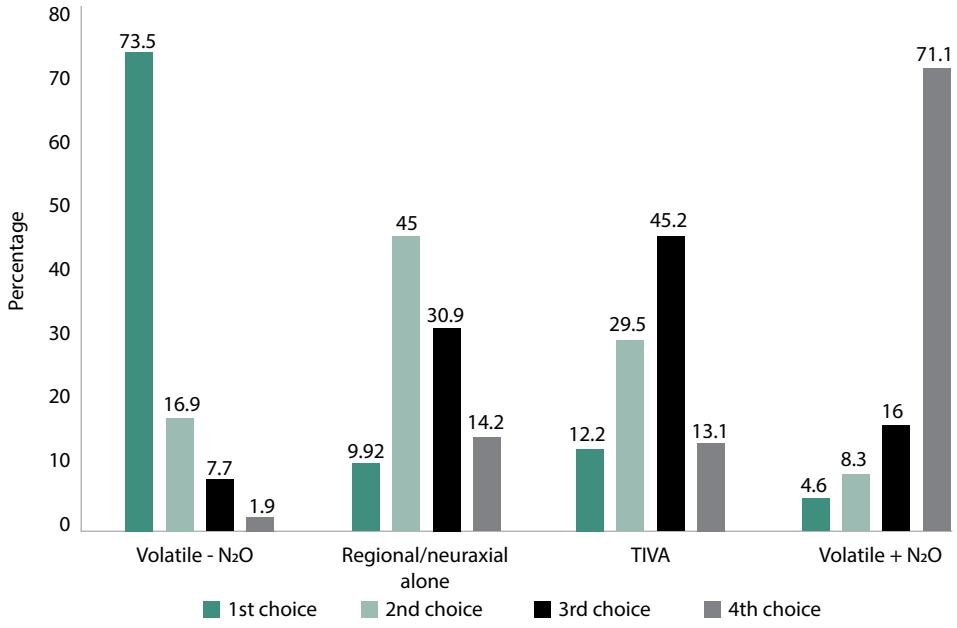

Figure 1: Different technique preferences ($p < 0.05$)

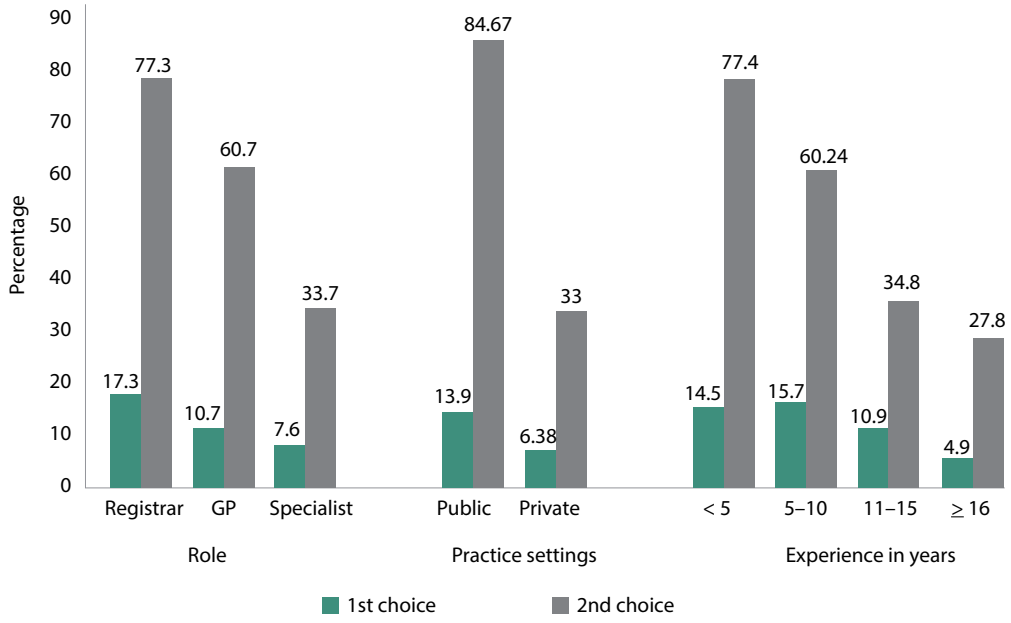

Figure 2: Regional/neuraxial-only preferences by different categories ($p < 0.05$)

Results

A total of 354 unique responses were received from 2 210 individuals who received a request for survey completion. The response rate was 16.0%. Demographic characteristics are illustrated in Table II. Most participants (63.0%) were 30–49 years old and had 16 or more years of experience (45.8%). Specialist anaesthesiologists accounted for 70.8% of respondents. Sole private practice accounted for 53.4% of respondents, and sole government practice for 38.7%. Only 3.7% of respondents are in combined private and government practice. Provincial representation was tracked with population density, except for the Free State, which accounted for 11.0% of respondents. The likely cause was increased awareness among the researchers' colleagues based in the Free State.

Figure 1 illustrates technique preferences. Most respondents' first-choice technique was a volatile without N_2O (73.5%). Regional/neuraxial-only techniques were chosen as the most common second choice (45.0%), followed by propofol TIVA as the most common third choice (45.2%). A volatile with N_2O was selected as the fourth choice by 71.1% of respondents.

Regional/neuraxial-only and propofol TIVA usage differed considerably depending on role, practice setting, and years of experience. Registrars chose regional/neuraxial-only as their first or second-choice technique significantly more than general practitioners (GP), and GPs more than specialists ($p < 0.05$). Moreover, practitioners in public practice significantly favoured regional/neuraxial techniques compared to their colleagues in private practice ($p < 0.05$). This trend continues when comparing

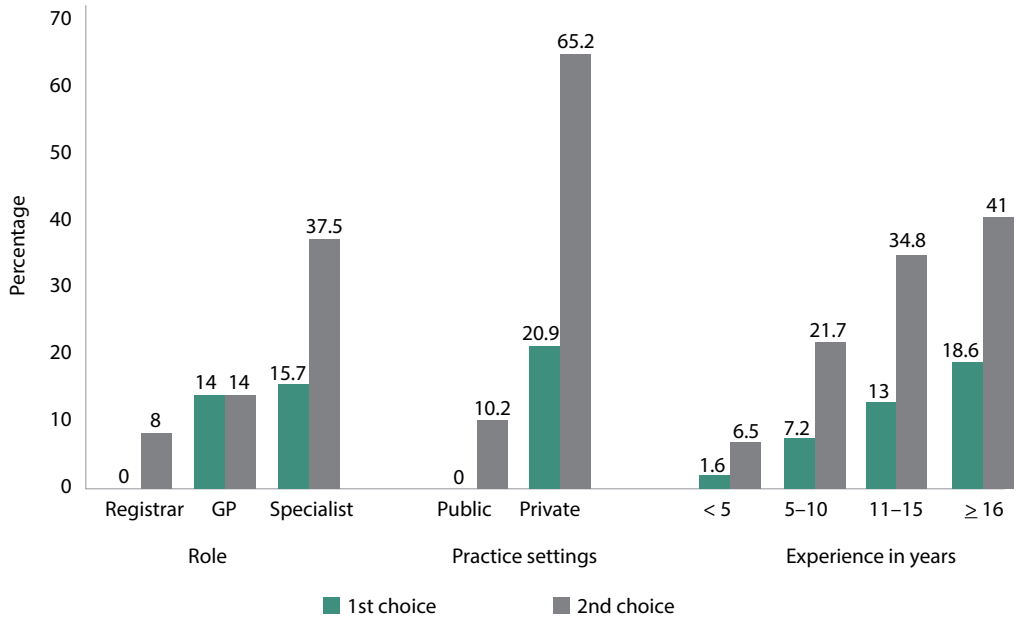

Figure 3: Propofol TIVA by different categories ($p < 0.05$)

anaesthetists with varying years of experience. Regional/neuraxial-only was chosen as the first or second choice more often by junior practitioners than senior practitioners ($p < 0.05$). Figure 2 illustrates these relationships.

The usage of propofol TIVA showed a reverse tendency (Figure 3). Zero registrars selected propofol TIVA as their first-choice anaesthetic technique, with only 8.0% of registrars choosing the technique as their second choice. Propofol TIVA is more prevalent under GPs and particularly popular under specialists, with 15.7% of specialists selecting the technique as their first choice and 37.5% as their second choice ($p < 0.05$). Furthermore, propofol TIVA is far more commonly used in private than public practice ($p < 0.05$). Lastly, experienced practitioners preferred propofol TIVA more than inexperienced practitioners ($p < 0.05$). Nearly one in five practitioners (18.6%) with 16 or more years of experience chose the technique as their first choice. Only 1.6% of anaesthetists with five years or less experience selected propofol TIVA as their first-choice technique.

Sevoflurane was selected as the first-choice volatile by 79.9% of respondents. Desflurane and isoflurane were popular second-choice volatiles, with 39.4% and 41.0%, respectively. Halothane was overwhelmingly the least preferred volatile, with 87.2% of respondents indicating it as their fourth choice.

Desflurane preferences varied considerably among different groups (Figure 4). Registrars prefer desflurane far less than GPs and specialists ($p < 0.05$). Private practitioners favoured desflurane more than public practitioners, with 25.5% of private practitioners choosing desflurane as their first choice, compared

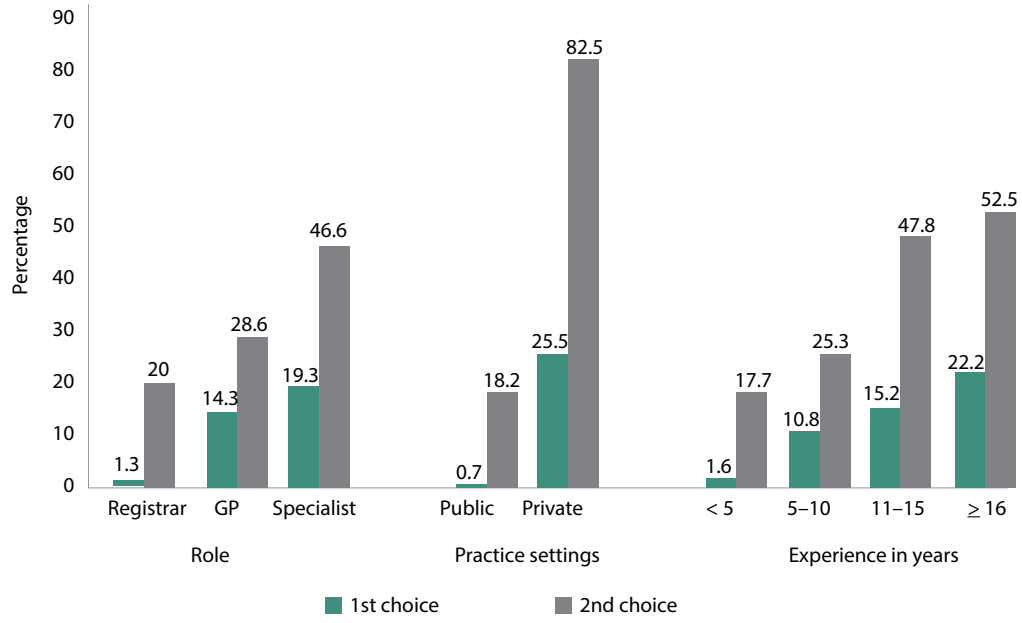

Figure 4: Desflurane preferences by different categories ($p < 0.05$)

to 0.7% of their public counterparts ($p < 0.05$). Moreover, desflurane was more often selected as the first or second choice by experienced practitioners compared to inexperienced practitioners ($p < 0.05$).

Automated end-tidal control software was reportedly used in more than 60% of their cases by 148 respondents (41.9%). However, 36.4% of respondents were unsure how often they used the software/function. A substantial number of respondents (26.8%) reported utilising WAG trapping devices. Low-flow (< 2 L/min) anaesthesia (when using a volatile agent) is commonly practised by 96.6% of respondents, with 18.1% of anaesthetists practising metabolic flows (FGF < 500 ml/min). This tendency continues for FGF when using propofol TIVA, with 84.7% of respondents reporting the use of low flows (< 2 L/min).

Breathing circuits were changed every 24 hours by 197 respondents (55.6%). Only 9.3% of anaesthetists changed circuits weekly, with a significant number (22.6%) reporting that they were unsure. Only 5.6% of specialists changed breathing circuits weekly, compared to 14.3% of GPs and 20.0% of registrars ($p < 0.05$). Moreover, senior (experienced) respondents were more likely to change circuits every 24 hours compared to junior (less experienced) respondents, who were more likely to change circuits weekly ($p < 0.05$).

More than four in five anaesthetists (81.9%) reported that they seldom or never used multiuse LMAs. Specialists were the least likely to use reusable LMAs, with nine in ten specialists (90.0%) reporting that they seldom or never use reusable LMAs ($p < 0.05$). In contrast, nearly nine in ten anaesthetists (88.9%) reported always or often using reusable laryngoscope blades. Registrars were most likely to reuse laryngoscope blades, with 97.3% of this group answering always or often to this question ($p < 0.05$). Most respondents (92.9%) indicated they seldom or never use prefilled syringes.

Most anaesthetists (93.5%) agreed or strongly agreed that climate change is a global health concern. Of note, the respondents who disagreed or strongly disagreed with this statement were all (100%) specialists ($p < 0.05$). Nearly a quarter of respondents (24.4%) disagreed or strongly disagreed that OR waste contributed disproportionately to hospitals' total environmental impact or that anaesthesia contributed significantly to the environmental impact of ORs (23.1%). Most respondents (77.6%) disagreed or strongly disagreed that education regarding the environmental impact of anaesthesia is sufficient. Two-thirds of anaesthetists (66.6%) agree or strongly agree that the environmental impact should be considered when formulating an anaesthetic plan. GPs (82.1%) and registrars (78.7%) were more likely to agree or strongly agree that the environmental impact should be a consideration compared to their specialist (59.7%) colleagues ($p < 0.05$).

Opinions on the sustainability of their practices were divided, with 46.7% of respondents disagreeing or strongly disagreeing that their practices are sustainable. More than nine in ten anaesthetists (93.4%) agreed or strongly agreed that they would like to recycle OR waste, but only 26.6% agreed or strongly agreed that their hospitals recycled OR waste. Only one in ten anaesthetists (11.1%) reported that their institutions have a sustainability programme or that they donated unused equipment (9.9%). The main barriers to improvement identified by respondents were the lack of education and information (72.3%), lack of support from hospital management (64.4%), and staff attitudes (62.2%).

Discussion

The data suggests that the most often used technique is volatile-based general anaesthesia (GA) carried in oxygen (O_2) and medical air. The preference for regional/neuraxial-only techniques and propofol-based TIVA is similar. Using a N_2O/O_2 carrier gas during GA with volatile maintenance is not frequently practised.

From the data, one can deduce that the practitioner who prefers regional/neuraxial-only techniques is junior (less experienced), a registrar, or a GP, and in public practice. This might be because of the recent increase in regional techniques described and performed in academic settings. Furthermore, senior specialists might not be as versed in newer regional techniques and adjuncts. In contrast, the practitioner who prefers propofol-based TIVA is a senior (more experienced) specialist in private practice. The explanation might be the increased knowledge needed to perform TIVA safely, combined with the requirement of specialised equipment and monitoring that might not be available in the public setting or to junior doctors.

There was no difference among the groups in using volatiles with or without N_2O; volatile maintenance without N_2O was the most popular, and volatiles with N_2O were the most unpopular. Thus, to decrease the environmental impact of anaesthesia, experienced specialists should be encouraged to perform more regional/neuraxial-only techniques. Moreover, junior GPs and registrars should be empowered and equipped to perform propofol-based TIVA.

Sevoflurane is the volatile of choice throughout South Africa. Isoflurane and desflurane show comparable preferences. Halothane is overwhelmingly the least favoured volatile commercially available. The data regarding desflurane paints an intriguing picture. Firstly, when considering desflurane's environmental impact, one would expect it to be less popular than the results show. Secondly, the anaesthetist who most likely prefers desflurane is a private specialist with 11 or more years of experience. The cause for this strong signal might be due to the availability of desflurane in private institutions and the relative unavailability in public institutions, combined with the increased pressure for a quick turnover in private. It is also possible that anaesthetists who completed their studies more than a decade ago are less aware of the environmental impact of desflurane. Sustainability in the private sphere can be improved through encouragement and education to use desflurane only for cases where its use is justified or indicated.

Volatile-based anaesthesia is overwhelmingly the most common anaesthetic delivered in the country. Thus, utilising available techniques to limit these anaesthetics' economic and environmental impact is imperative. Only 41.9% of respondents reported using end-tidal control software in more than 60% of their cases, with more than one-third unsure. Surprisingly, 26.8% of anaesthetists reported utilising WAG trapping/destroying technology. There is a possibility that respondents confused WAG trapping/destroying with scavenging or even carbon dioxide (CO_2) absorption. If not, this is a promising sign but must be investigated further to confirm. During volatile-based GA, low FGF (< 2 L/min) is commonly practised, but only 18.1% commonly employ basal flow (< 500 ml/min) in this situation. This is reassuring, but unfortunately, this tendency continues for propofol TIVA, with 84.7% of anaesthetists using low FGF during TIVA. The literature suggests that using FGF from 2 L/min to 4 L/min might be more sustainable and safe during TIVA.[28]

Concerningly, more than half of respondents reported changing breathing circuits every 24 hours, and only 9.3% changed circuits on the recommended weekly basis.[29] Furthermore, senior anaesthetists and specialists perform 24 hourly circuit changes more regularly than junior anaesthetists. This trend continues with more than four in five respondents who seldom or never use reusable LMAs. Specialists are again less likely to use reusable LMAs than their more junior colleagues. Less than one in ten anaesthetists use prefilled syringes. The high utilisation rate of reusable laryngoscope blades is a break in the trend.

Most South African anaesthetists feel that climate change is a concern. Interestingly, all those respondents who are not concerned about climate change are specialists. A quarter of anaesthetists disagree with the scientifically proven fact that ORs, specifically the provision of anaesthesia, contribute disproportionately to the environmental impact of the healthcare system. This suggests that knowledge of our daily practises is lacking. Appropriately, most anaesthetists agree that education regarding sustainability is insufficient. Only two-thirds of respondents considered the environment when planning their technique. Of these, GPs and registrars were more likely to consider the environment compared to specialists. Only a quarter of respondents recycle OR waste, and almost half do not consider their practice sustainable. The willingness to improve is evident through the high percentage of respondents (93.4%) who expressed the desire to recycle waste. Only one in ten respondents reported that their institutions have a sustainability programme or donated unused medical equipment instead of discarding it.

The barriers identified in this study concurred with findings from international literature, with a lack of education and management support and obstructive staff attitudes listed as the most problematic areas.[24,25]

Limitations

The study's response rate was low, at 16.0%, making the results less generalisable. Secondly, practitioners who are more sustainably inclined might have been more likely to participate in the study. Lastly, there was an overrepresentation of both private and specialist anaesthetists. These limitations might have skewed the data. Nevertheless, this is the most comprehensive local study of its nature to date.

Conclusion

This study shows that South African anaesthesia providers have considerable areas to improve regarding sustainability and limiting the environmental impact of their practices. Apparent areas include restricting volatile anaesthetics and substituting them with propofol TIVA and regional/neuraxial techniques. Furthermore, the study shows that OR waste management can be improved.

A unique finding of this study is the contrasting practices of the private and public sectors; often, where one performs well, the other lags. A second feature is the contrast between senior and junior practitioners; again, one group is better in certain aspects but fails in others. This demonstrates the necessity of collaboration between different groups to improve sustainability throughout the healthcare sector.

This work confirmed similar barriers in previous studies. It follows that leaders should try to improve access to information, mount a concerted effort to improve or reform institutional memory, and influence OR staff to shift attitudes. Likewise, a thorough understanding of the context in which we practice is required before making alterations in the name of sustainability. For this reason, South African-specific research and life-cycle analysis (LCA) should be performed to identify the most sustainable methods of practising our profession.

Specific results are reassuring. For example, the dominant use of an environmentally friendly volatile agent, the reuse of certain products, the eagerness to learn and innovate, and the emergence of a new generation of anaesthetists seemingly more engaged in sustainability. If combined with novel technology, South African anaesthetists can create a future where our discipline can be practised with less detriment to our planet.

Conflict of interest

The authors declare no conflict of interest.

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Ethical approval

Before the study commenced, ethical approval was obtained from the following ethical review board: Health Sciences Research Ethics Committee, reference number UFS-HSD2022/0735/3008.

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