Article

Strategies for Achieving Sustainable Anesthesia: Insights from Austrian Experts—A Qualitative Interview Study

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Abstract: The implementation of low-carbon healthcare practices will be significantly enhanced by the role of anesthesia personnel. While there is a lack of data on the specific measures being implemented by anesthesia departments in Austria, we conducted interviews with six experts in sustainability within anesthesia to address this knowledge gap. These experts provided insights on strategies for reducing the CO$_2$ impact in the operating theatre, the level of interest among anesthetists in sustainability, the role of green teams in hospitals, and future prospects for sustainable anesthesia. While Austria has made progress in reducing the use of Desfluran, waste separation within operating theatres remains a significant issue. Green teams are present in hospitals, but there is a need for the greater inclusion of anesthetists and clinical staff. The topic of sustainability is becoming increasingly important in the field of anesthesia, and the past three years have witnessed a significant push towards reducing CO$_2$ emissions in hospitals across Austria. The experts identified key steps towards achieving sustainable anesthesia, emphasizing the need for an internal motivation to drive meaningful change. This study highlights the numerous measures that have already been implemented in the pursuit of sustainability in anesthesia and the ongoing efforts towards further improvement.

Keywords: sustainable health; anesthesia; waste; green teams; climate change

1. Introduction

Scientific evidence is clear: as the intergovernmental panel of climate change states, there is a rapidly closing window for opportunities to change our way to a sustainable and green future for humanity [1]. The IPCC models show that immediate reductions in greenhouse gas emissions across all sectors are necessary in order to limit global warming to 1.5 °C [2]. The healthcare sector is also involved in this effort and must address two challenges concurrently: the growing health impacts of climate change and the need to reduce its own carbon footprint, which is estimated to be 4.4% of global emissions [3].

In developed countries with substantial financial resources, anesthesia-related activities generally contribute more to greenhouse gas emissions than those in middle- and low-income nations. However, the adverse consequences of climate change tend to manifest more severely in these countries [3]. As emerging economies progress and expand, it is expected that the carbon emissions from healthcare, particularly anesthesia, will rise in these nations [4].

The contribution of personnel in anesthesia is vital for the transition to low-carbon healthcare. In their daily work processes, they can make a significant impact on global carbon emissions in healthcare by focusing on areas such as the reduction in volatile anesthetics, waste, and energy consumption [5].

Limited research has been conducted on the understanding and perspectives of anesthetic practitioners regarding sustainable anesthetic practices. Earlier research involving anesthesiologists suggests a notable deficiency in the knowledge of sustainable practices and significant room for improvement [6,7].
1.1. Volatile Anesthetics

Volatile anesthetics consist of halogenated hydrocarbons and are, therefore, categorized as greenhouse gases. When evaluating the environmental impact of various volatile anesthetics, it is important to consider their potency in contributing to climate change. In comparison to carbon dioxide (CO$_2$), volatile anesthetics exhibit significantly a higher global warming potential (Table 1). To facilitate comparisons, these potent greenhouse gases can be converted into CO$_2$ equivalents (Equation (8)) [8].

Table 1. CO$_2$ equivalents of volatile anesthetics [9,10].

<table>
<thead>
<tr>
<th></th>
<th>Years in the Atmosphere</th>
<th>Global Warming Potential 100 Years</th>
<th>Global Warming Potential 20 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO$_2$</td>
<td>5–200</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Nitrous oxide N$_2$O</td>
<td>114</td>
<td>298</td>
<td>289</td>
</tr>
<tr>
<td>Desfluran</td>
<td>9–21</td>
<td>893–2540</td>
<td>6.810</td>
</tr>
<tr>
<td>Isofluran</td>
<td>2.6–6</td>
<td>191–510</td>
<td>1.800</td>
</tr>
<tr>
<td>Sevofluran</td>
<td>1.1–5.2</td>
<td>48–130</td>
<td>440</td>
</tr>
</tbody>
</table>

Desflurane is widely considered to be the most detrimental of the volatile anesthetics due to its high global warming potential, which is estimated to be up to 2500 times greater than that of carbon dioxide. In contrast, sevoflurane, with a global warming potential of 130 times greater than CO$_2$, is significantly less harmful to the climate [11].

The flow of fresh gas during anesthesia has a major influence on CO$_2$ equivalents. As shown in Table 2, there was an almost linear increase in emissions during anesthesia. It compares a six-hour-long anesthesia with the length of a car journey in a mid-range car, depending on the used volatile anesthetic and fresh gas flow [12].

Table 2. Comparison of the GWP for 1 year in a steady-state anesthesia with different volatile anesthetics, depending on the fresh-flow-rate based on kilometers driven by car (usage of 7 L per 100 km) [12].

<table>
<thead>
<tr>
<th>Volatile Anesthetic</th>
<th>Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.3 L/min</td>
</tr>
<tr>
<td>Sevofluran 2.2%</td>
<td>563</td>
</tr>
<tr>
<td>Isofluran 1.2%</td>
<td>436</td>
</tr>
<tr>
<td>Desfluran 6.7%</td>
<td>2.865</td>
</tr>
</tbody>
</table>

To reduce the impact of volatile anesthetics, collection systems that enable their recycling are now available. In addition, there are technical options for anesthesia machines that can significantly reduce the consumption of volatile anesthetics and, thus, make a relevant contribution towards reducing climate impact emissions [13].

1.2. Waste

Approximately 10–20% of the healthcare sector’s total CO$_2$ footprint is estimated to be caused by waste [14,15]. A large proportion, around 20–30%, of hospital waste is generated in operating theatres. Of these, 25% came from the anesthesia department alone, which is a significant proportion [16]. The majority of waste can be explained by the increase in disposable items in hospitals, which have accounted for the majority of materials used in recent years. In addition, the increasing number of operations is another factor that causes the mountains of waste from anesthesia to continue to grow [17]. During an operation, an average of 7.62 to 16.39 kg of waste is produced [14].

According to information from the World Health Organization (WHO), challenges concerning healthcare waste include a lack of awareness about the health risks associated
with it, insufficient training in effective waste management, the absence of proper waste administration and disposal systems, inadequate economic and human resources, and insufficient focus on the issue [18]. Environmental pollution can cause infectious diseases, and clinicians must develop healthier ecosystems. While treating patients, most healthcare institutions use disposable products to prevent or minimize infections. Only 15% of the medical waste is considered hazardous (infectious or toxic). Therefore, 85% of it is so-called non-hazardous waste, such as packaging or medical supplies (i.e., gloves and masks, among others) [18,19].

Implementing cost-effective strategies can significantly decrease the amount of medical waste generated by healthcare institutions. For instance, adopting systems that utilize high-temperature/pressure and chemical processes to sterilize medical equipment and materials can greatly reduce waste. Additionally, the effective sorting of discharged waste can be implemented to further minimize waste. The Great Ormond Street Hospital in London serves as an illustrative example of the potential cost savings achievable by reducing plastic waste. Specifically, by implementing employee training programs aimed at promoting the appropriate usage of disposable plastic gloves, the hospital was able to eliminate approximately 21 tons of plastic waste and realize savings of approximately USD 120,000 [19].

In order to address the aforementioned challenges, the concept of the 5 Rs (Reduce, Reuse, Recycle, Rethink, and Research) has been implemented and has been effective since its inception [20]. However, information on the practicality of reusing materials in accordance with sanitary regulations is not universally accessible for various devices, device components, consumables, etc. Furthermore, the feasibility of reprocessing also depends on factors such as the manufacturer, local conditions, and type of energy supply available.

1.3. Energy

Heating, ventilation, and air conditioning (HVAC) systems account for a significant proportion of energy consumption in operating theatres, often constituting 90% to 99% of the total energy usage. This highlights the critical role that energy plays in anesthesia and hospitals. Electricity, which is a key component of HVAC systems, is often generated from fossil fuels [5]. Hospitals should explore alternative means to curb their substantial energy consumption. Implementing a photovoltaic system to generate a portion of the necessary electricity is one such solution. It is also advisable to insulate remodeled or newly constructed buildings to the latest standards, which would significantly reduce energy usage for heating purposes [21]. Generally, reducing energy consumption is crucial; examples include switching off or even disconnecting devices when not in, refraining from leaving lights on unnecessarily, employing motion detectors, and other similar practices [22].

These are just a few points of recommendation that anesthetists worldwide publicize in terms of sustainability in anesthesia. With this work, we aim to obtain a brief overview of sustainability in anesthesia within Austria. Therefore, we interviewed six experts in this field.

Driving a shift towards low-emission anesthetic practice allows anesthetic health personnel to play a crucial role in mitigating the impact of climate change on global health and its far-reaching consequences. Additionally, it serves as an example for other areas of medicine to follow in achieving sustainable low-carbon operations, and sustainable healthcare [23].

2. Materials and Methods

2.1. Study Sample and Design

This research was executed as a prospective, qualitative study through the administration of semi-structured interviews to a select group of experts. The study was conducted at the Medical University of Graz. Due to the absence of clinical data in this investigation, it was deemed exempt from requiring approval from ethics committees, as per both national and European regulations.
Our sample consisted of experts in sustainable anesthesia in Austria who are members of the platform for sustainable anesthesia and intensive care medicine. This platform is part of the Austrian Society for Anesthesiology, Resuscitation, and Intensive Care Medicine (ÖGARI), and its members include physicians from different hospitals across Austria. When conducting the interviews, the platform counted 26 members. We invited one member of each state in Austria (n = 9). The invitation was sent via e-mail, and a subsequent reminder was dispatched after a period of one month. This correspondence succinctly delineated the subject matter and objectives of the investigation.

After acceptance, the experts had to decide whether to conduct the interviews via phone or Microsoft Teams and to receive an interview date. Oral informed consent was obtained immediately before the interview. Semi-structured interviews were conducted using Microsoft Teams or mobile phones and recorded. We used interview guidelines developed by the first author. As reference for the interview guideline, the position paper with the title “Ecological Sustainability in Anesthesiology and Intensive Care Medicine. A DGAI and BDA Position Paper with Specific Recommendations” of Schuster et al. were used [10]. We focused on the main topics and problems of sustainable anesthesia, which were summarized into four topics: “how do you and your colleagues reduce CO\textsubscript{2} impact in the operating theatre?”, the interest of physicians in anesthesia in sustainability, green teams in hospitals, and future trends of sustainability in anesthesia.

2.2. Data Collection and Analysis

The duration of data collection was four months (September to December 2023). The interviews, with one exception, lasted between 25–70 min and were conducted by one researcher. For this study, ethical approval from an ethics committee was not required according to Austrian law. Experts consented to participate in the study and recorded the interviews under the commitment of strict confidentiality and anonymization regarding the reporting of their answers in scientific publications.

The transcriptions of the interviews were undertaken using HappyScribe AI-driven software (Happy Scribe Ltd., Dublin, Ireland), and was subsequently manually refined to correct for any errors in terms of content and typography. The ensuing analysis of the interviews was carried out in accordance with the principles of quality content analysis by Mayring such as:

- documentation of method;
- interpretation safeguards;
- proximity to the object;
- rule-boundedness;
- communicative validation;
- triangulation [24].

The finalized text was subsequently subjected to a review by a second researcher.

3. Results

Ultimately, the total number of participants was six (response rate of 66.6%), including two female and four male experts. All participants worked as hospital-based anesthetists with various positions. The sample included two chief physicians, three attending physicians, and one resident physician. They represent the states of Carinthia, Salzburg, Styria, Tyrol, Vorarlberg, and Vienna, and, therefore, 61.1% of the Austrian population (Table 3). Other members declined the invitation because of a lack of time or interest, and some did not answer at all.

We identified four major topics while conducting the interviews and categorizing the results (Table 4). First, we focused on actions to reduce the CO\textsubscript{2} impact in the operating theatre. What is done by experts and their colleagues, and what can be done? For the second topic, the aim was to identify the interest of anesthesia physicians in sustainability and how to motivate them. The third topic concerned green teams in hospitals; this is
important, as they discuss problems and solutions to sustainability in healthcare. Lastly, we discussed the future of sustainability in anesthesia and the directions it might go.

Table 3. List of experts.

<table>
<thead>
<tr>
<th>Experts</th>
<th>Gender</th>
<th>Position Inside Clinic</th>
<th>Number of Beds of the Clinic</th>
<th>State Inside Austria</th>
<th>Type of Interview</th>
<th>Interview Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>female</td>
<td>Attending physician</td>
<td>233</td>
<td>Salzburg</td>
<td>Telephone</td>
<td>20 min</td>
</tr>
<tr>
<td>E2</td>
<td>male</td>
<td>Head of department</td>
<td>619</td>
<td>Vorarlberg</td>
<td>Telephone</td>
<td>25 min</td>
</tr>
<tr>
<td>E3</td>
<td>female</td>
<td>Attending physician</td>
<td>1550</td>
<td>Tyrol</td>
<td>Webex (online)</td>
<td>70 min</td>
</tr>
<tr>
<td>E4</td>
<td>male</td>
<td>Resident</td>
<td>1706</td>
<td>Vienna</td>
<td>Webex (online)</td>
<td>50 min</td>
</tr>
<tr>
<td>E5</td>
<td>male</td>
<td>Attending physician</td>
<td>1551</td>
<td>Styria</td>
<td>In persona</td>
<td>25 min</td>
</tr>
<tr>
<td>E6</td>
<td>male</td>
<td>Head of department</td>
<td>613</td>
<td>Carinthia</td>
<td>Telephone</td>
<td>40 min</td>
</tr>
</tbody>
</table>

Table 4. Results/statements of the interviews.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Statements</th>
<th>Approval Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>How to reduce CO(_2) impact in the operation theatre</td>
<td>Ban desflurane and N(_2)O</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Use minimal or metabolic flow whenever possible</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Establish a waste separation system</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Prefer TIVAs instead of volatile anesthetics</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td>Prefer reusable over disposable products</td>
<td>83%</td>
</tr>
<tr>
<td>Interest of anesthesia physicians in sustainability and how to motivate them</td>
<td>Older anesthetists are less interested in implementing sustainability measures than the younger generation</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td>Spread information with presentations and transparency</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td>Better communication between heads of department and colleagues</td>
<td>66%</td>
</tr>
<tr>
<td></td>
<td>Scientific evidence with study results</td>
<td>33%</td>
</tr>
<tr>
<td>Green teams in hospitals</td>
<td>A green team is needed in every hospital</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Anesthesia is part of the green team in the expert’s hospital</td>
<td>66%</td>
</tr>
<tr>
<td></td>
<td>Green teams all over Austria should have identical structure to improve information exchange between them</td>
<td>83%</td>
</tr>
<tr>
<td>Future sights</td>
<td>Quitting the usage of desflurane will have a major impact on the anesthesia balance sheet</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Move from disposable to reusable products offers great potential</td>
<td>83%</td>
</tr>
<tr>
<td></td>
<td>Regular lifecycle analyses for products used in the operation theatre are another major point</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td>Personal conviction and political commitment will take a major role within sustainable anesthesia</td>
<td>100%</td>
</tr>
</tbody>
</table>

3.1. Expert’s Opinions on How to Reduce the CO\(_2\) Impact in the Operation Theatre

All experts agreed that there is an urgent need to reduce the CO\(_2\) impact of anesthesia and have different opinions on how to achieve this. The unanimous viewpoint among them was to prohibit the utilization of Desfluran and N\(_2\)O in the operating theatre. Both have
a significant influence on the environment and, when considering their medical benefits, are without advantage compared to their equivalent sevoflurane. Another consensus is that the utilization of minimal or metabolic flow during sevoflurane anesthesia represents a simple yet effective method for reducing carbon dioxide emissions. This approach is within the purview of every anesthetist and can lead to significant environmental benefits. All experts agreed that ensuring patients’ safety is of paramount importance and should always be prioritized; thus, there exist circumstances and situations in which these actions cannot be applied.

According to five of the six experts, implementing an organized method for waste separation in the operation theatre is crucial. Unfortunately, some hospitals lack an adequate system and dispose plastic, medical waste, and packaging into a single container. To address this issue, experts recommended that staff in the operating theatre receive frequent training in using a five-container system, which allows for the separation of packaging, glass, plastic, medical waste, and normal waste.

The next viewpoint originated from two experts, who indicated that they generally preferred using total intravenous anesthesia (TIVAs) over volatile anesthetics. In the case of TIVAs, the anesthetic agent propofol at a concentration of 2% was employed. The argument opposing the use of propofol is that it must be disposed of appropriately, which is not always the case in healthcare facilities [25].

The last proposal is to return to reusable products and get away from disposable products. In recent years, hospitals have commonly relied on disposable medical supplies. Despite this widespread usage, there is little scientific evidence to support the notion that single-use devices improve patient safety. Neither the existing body of literature nor national or international guidelines have provided conclusive proof. The environmental costs of disposable medical products, including greenhouse gas emissions, energy consumption, water use, waste volume, and raw material depletion, have been documented extensively. In contrast, reusable products are more eco-friendly and, in some cases, economically advantageous compared with their disposable counterparts. Consequently, curtailing the reliance on disposable devices within hospitals should be among the array of strategies employed to mitigate the environmental footprint [26].

3.2. Is There a Lack of Interest in Sustainability among Anesthesiologists?

Another part of the interview concerned the interests of participants’ colleagues. All experts independently stated that there was rising interest in the topic. There is, however, a varying degree of interest across different departments, with some showing greater enthusiasm than others. Participants E3 and E5 criticized the fact that there was a general interest, while, at the same time, there was an absence of concrete steps towards implementation. A relatively small number of individuals have demonstrated readiness to effectuate change and drive sustainability initiatives forward. As their knowledge base expands, so does their inclination to take proactive measures towards achieving sustainability goals.

Older colleagues are equally interested and informed as young anesthetists. Senior physician E5 made it clear that there is no generational problem in his hospital. In another view, participants E4 and E6 said that older anesthetists are less interested in implementing sustainability measures than the younger generation. They stated that it is more difficult to bring change and rethink when colleagues have been used to their procedures for more than 20 years. According to them, patience and education are appropriate approaches. Expert E6 noted that young anesthetists are increasingly demanding sustainability and that how the hospital deals with the issues of sustainability and climate protection is a decisive factor for them when applying for jobs.

At the end of this thematic block, the participants were asked what needs to be done to convince their colleagues of sustainability. Their answers varied and highlighted several aspects of this topic. Two experts agreed that information plays a key role in persuasion. In addition to information, transparency has been mentioned as an important
tool. Another aspect that connects with this is communication, which is named by most experts. The opinion is that without well-functioning communication between the head of the department and his employees, persuasion cannot work. In addition to communication, the willingness of the respective colleagues to want to change something was mentioned. Presentations or information can only motivate people to a certain extent, but you cannot get everyone on board that way. The topic of general awareness-raising is at the center of the work of members of PNAI and needs to be promoted more widely among the population. Finally, one expert suggested that scientific evidence plays an important role when arguing with colleagues. With the study results and published articles in renowned journals, there is a basis for change.

3.3. Are Green Teams as Common as They Should Be?

The participating hospitals each have green teams, but their organization and functioning vary among them. The departments of four experts have a purely anesthesiologic green team. These are actively supported by the respective department heads and can, therefore, organize themselves well. Projects are planned and implemented within these teams, and training courses are organized for the entire department. The green teams meet on a quarterly basis every year and try to discuss relevant topics. Although there is a green team at expert E1’s hospital, according to her, it consists only of administration, the kitchen, and building services. Unfortunately, the operating theatre and other departments were not represented. According to anesthetist A5, there is probably a green team in the administration area, although there are no points of contact with it. An anesthesia green team is currently being established, and active members are still being sought. Green teams have now arrived at most clinics, but they still seem unstructured or structured differently in terms of their activities and areas of responsibility.

3.4. Future Sights of Sustainability in Anesthesia

The last question in this interview was about the future potential of sustainability within anesthesia. The experts agree that there is still a lot of potential for improvement in this area and that there will be many groundbreaking changes in the coming years that will be groundbreaking for the future. All of them believe that reducing volatile anesthetics will continue to be a significant issue. Quitting the use of desflurane will have a major impact on the anesthesia balance sheet, and the shift from disposable to reusable products offers equally great potential. Regular lifecycle analyses are another major point for the future of two experts. This enables better comparisons between different providers and provides a better overview of the products used. Each participant had different views on what would be important for increasing the focus on sustainability. Participants E1 and E3 agreed that personal conviction is an essential factor. Without a connection to this issue, it is not possible to act, which is why presentations and regular exchanges of information are very important. Additionally, political commitments should not be underestimated. If the government demands a climate-neutral hospital or healthcare system, all stakeholders are obliged to deal with these tasks and measures. One of the experts emphasized that benchmarking and the production of sustainability indicators are very important. This would enable standardized comparisons between various hospitals, and the so-called competition for sustainability could emerge. The ambitions of individual hospitals are awakened. In addition, the regular exchange of information within and outside the anesthetic society is also important.

4. Discussion

Our results indicated that diverse approaches exist for promoting sustainability within the context of anesthesia and to minimize the carbon emission associated with anesthesia. Notably, the experts mentioned almost identical options independently. The measures with unanimous agreement include the following:

- The reduction of fresh gas flow;
• The banning of desflurane and N\textsubscript{2}O;
• Waste separation within the operating theatre;
• Multidisciplinary green teams including anesthesiology;
• Personal conviction and political commitment.

The majority of these measures are straightforward and can be implemented independently. All of the experts’ recommendations are based on clear scientific evidence, which is analyzed in more detail in the review of the literature below [7,13,15,22,27–31].

4.1. Reducing Fresh Gas Flow

Managing fresh gas flow in order to reduce environmental contamination has been promoted for more than a decade [27]. It has a direct effect on the consumption of volatile anesthetics. Reducing the flow from 2.5 L/min to 1 L/min reduces the costs by 48% and the CO\textsubscript{2}e by 42% [32]. A further reduction to 0.35 L/min, which is, however, only suitable during stable phases of anesthesia, could decrease emission even by 50% [30].

Until recently, environmental consequences of high fresh gas flow were, however, neither broadly discussed in clinical routine nor included in training. Therefore, many anesthesia providers are unaware of the impact of their clinical practice [33]. In addition to spreading information and incorporating formal training, new technologies may also help to reduce fresh gas flow. Automated gas control, which sets anesthesia gas dosing and fresh gas flow in order to ensure the desired end-tidal concentrations, was shown to efficiently reduce anesthesia gas consumption by 33% compared to manual control [34].

4.2. Banning Desfluran and N\textsubscript{2}O

Implementing the discontinuation of desflurane due to its significant environmental impact and impact on the climate should be the first step taken. From an anesthesiologic point of view, desflurane has no advantages compared to sevoflurane, making it a straightforward decision for hospitals to transition to a more eco-friendly alternative [30]. The National Health Service of Scotland has entirely banned Desfluran in 2023 and the NHS of England is already planning to do the same in 2024 [35].

A recent single-center study in Zurich, Switzerland also confirmed statistical evidence in the implementation of sustainable measures, including banning Desfluran, the promotion of TIVA, and limiting inhalational anesthetics to a clear list of specific indications. Gasciauskaite et al. compared the environmental and financial impact before and after the intervention. The environmental impact decreased from 3 (0–7) CO\textsubscript{2}e in kg per case to 1 (0–3) CO\textsubscript{2}e in kg per case—which means an 81% reduction in terms of cumulative CO\textsubscript{2}e emissions. The costs were 11% lower. The economic impact decreased from 25 (13–41) CHF per case to 21 (14–31) CHF per case. These findings meet the conclusions our experts made within this study [28].

4.3. Waste Seperation and Training

Implementing mandatory training sessions for staff members working in operating theatres at regular intervals is crucial for promoting effective waste separation and reduction practices. This approach ensures that all employees receive the necessary information to carry out their responsibilities efficiently [28]. A study team in the USA could show the significance and feasibility of an educational intervention in waste reduction for anesthesia providers. During each study period (pre- and post-intervention), the average weekly waste generation was compiled and examined per 100 surgeries. Their average weekly waste for endotracheal tubes experienced a notable reduction from 26.7 ± 10.7 to 10.0 ± 6.1, indicating a significant 62.6% decrease from pre- to post-intervention (p < 0.001). Similarly, significant reductions were observed for laryngoscope handles (15.9 ± 8.1 vs. 7.2 ± 3.1; p = 0.004; a 54.7% reduction) and laryngoscope blades (21.5 ± 11.0 vs. 9.9 ± 4.4; p = 0.004; a 54.0% reduction). As our experts indicate, proper waste management measures in anesthesiology have an impact and need to be taken [36].
For patients who are not in critical condition, it is imperative that measures be taken to minimize this as much as possible. Misinformation or the desire for convenience should not serve as justification for inaction and can be remedied through education and the sharing of best practices amongst colleagues.

Another point addressed is the importance of using reusable products. A multitude of medical facilities have shifted to disposable items, as these products pose fewer hygiene concerns and do not require sterilization [37]. Koch and Pecher also showed that this argument is no longer relevant, and that there is no need to worry about hygiene when transitioning from disposable to reusable products. The capacity of the hospital’s sterilization unit plays a critical role in this changeover. Furthermore, the use of reusable products not only supports sustainability, but can also decrease hospital expenses [38].

4.4. Multidisciplinary Green Teams Including Anesthesiology

The absence of environmental awareness across all levels, including management, doctors, and nurses, in conjunction with the substantial number of stakeholders involved, poses a significant obstacle to the implementation of environmentally sustainable practices. To tackle this issue, the formation of multidisciplinary teams dedicated to environmental sustainability within hospitals or hospital networks could provide a partial solution. These “green teams” have to receive specialized training on theoretical, practical, and regulatory aspects of sustainability and would work to enhance staff awareness and improve communication on these issues among the various stakeholders [39]. Due to the various negative environmental impacts of perioperative medicine already described here, it is pivotal that anesthesiologists must be represented in such teams.

In our interviews, each expert revealed in the interviews that a green team exists in their hospital. However, there were differences in structure and tasks. In four of them, the anesthetists are members of these green teams and help shape their agenda. This makes sense, as the anesthesia department and operating theatres make an enormous contribution to CO$_2$ emissions [40]. This makes it more questionable that two experts stated that, although there is a green team in the hospital, it only includes members of the administration. The projects and plans are only planned and implemented from their point of view, which means that the perspective of clinical workers has not been heard [41]. Nevertheless, there is positive development, as there is a green team in every hospital, regardless of how it is structured. It is possible to build on this and involve various green teams in further development and projects. In addition to operating theatres, intensive care units are another major emitter of CO$_2$ in hospitals. Trent et al. showed how important it is to introduce a green team in these areas as well, as there is enormous potential for CO$_2$ savings. They highlighted how to set up a green team and how important it is to motivate and inform other staff [42].

At Seattle Children’s Hospital, a multidisciplinary green team was formed including members of anesthesiology, surgery, and nursing. Based on their knowledge, they started with their first interventions in 2017 and, in the following 4 years, the CO$_2$ emission in operating theatres decreased from 570 tons CO$_2$e to 166 tons CO$_2$e in 2021, representing a reduction of 71%, which indicates how important a multidisciplinary green team is [43].

4.5. Personal Conviction and Political Commitment Will Take a Major Role

Although some approaches can be realized on an individual level and by a bottom-up movement, it is undeniable that major developments can only be accomplished if there is a clear commitment from the top [44]. The experts of our survey were in complete agreement in their description of future prospects. However, their view also corresponds exactly to what a recently published survey of Canadian doctors showed [45]. Several strategies were identified to accelerate the delivery of net-zero healthcare systems. To start, governments and healthcare organizations should make ambitious pledges to attain net-zero emissions in healthcare and its supply chains by a specific date, along with plans and funding to achieve this goal. Additionally, healthcare facilities should establish paid
interdisciplinary teams to create local policies and quality improvement initiatives aimed at decarbonizing care delivery, procurement, and energy, water, and waste management at their location. Furthermore, research funding institutions and universities should prioritize research that generates evidence and concepts to enhance healthcare sustainability and enable faculty members to engage in this work. Lastly, higher education institutions should incorporate education on healthcare sustainability and planetary health into their curricula for health professions.

A survey of US and Canadian anesthesia department chairs showed a heightened level of activity in relation to a wide range of environmental sustainability measures when environmental sustainability was taken into account in the annual performance appraisal [46]. It can be concluded from this that, by defining sustainability as a relevant goal, stakeholders can have a significant influence on the development of this area.

4.6. Other Relevant Findings

It is clear from the experts’ views that more people need to be activated and motivated in favor of sustainability. Most experts succeeded in doing this by means of training, awareness-raising, and the like [47]. Most young anesthetists are very interested in this topic and usually already have prior knowledge [48]. Unfortunately, the interviews showed that it can be difficult to implement measures due to a lack of support from hospital or department management. Petre et al. and her team (2019) also encountered a similar problem in Canada, where participants found that a lack of support from the leadership or hospital is a common issue and a barrier to moving towards environmental sustainability.

Out of 400 anesthesiologists participating in their survey, 251 (63.5%) answered that there was a lack of support from the hospital and/or leadership [29].

The flow of information within Austria could be greatly improved to achieve networking across provincial borders. The first step in this direction has already been taken with the establishment of the Platform for Sustainability in Anesthesia and Intensive Care Medicine of the ÖGARI. A study conducted in France by Tordjman et al. from 2022 shows that the flow of information must be stepped up and expanded further. The lack of support from management functions is also cited here as a point of criticism, which stands in the way of the further development of sustainability in the workplace [39].

In everyday life, it is often suggested that young people in our society care far more about the environment and sustainability than the older generation. One question in the interviews was intended to shed more light on this topic, and the results showed that four out of six experts did not support these statements. These four statements clearly show that interest is present in both groups and that there is no age difference. These results are not surprising, as Lindholm et al. (2023) came the same conclusion as these four experts with their survey in Norway [23]. The fact that both groups have different reasons and motivators for their actions was partially discussed in the interviews. Anesthetists who are not far away from their retirement are less involved in major changes and projects than young colleagues who still have more than 20 years of service ahead of them [31]. Nevertheless, these colleagues also take climate protection and sustainability seriously and are largely prepared to implement even minor measures such as not using desflurane.

To arouse the interest of anesthetists, information and training were mentioned most frequently by experts. Considering the thematic blocks of the major anesthesia congresses over the last two years, sustainability is a growing part of them. Societies are attempting to develop and publish recommendations so that departments can use them as guides when implementing sustainability [49]. Nikendei et al. (2020) have successfully demonstrated these aspects in their 2020 work. It is important that there is a sensible flow of information to motivate employees to become sustainable. Their research also mentioned the influence of political movements and the role of employers in promoting sustainability. They play a leading role in the distribution of information and the promotion of new projects. Without the commitment of multiple stakeholders, it will be difficult to create sustainable ways of working in hospitals and teams [50]. A team of researchers in South Korea could...
demonstrate the effect of education in terms of sustainable anesthesia. Changes in CO\textsubscript{2}e before and after education in actual clinical situations were observed. The driving equivalent of total anesthetics decreased significantly from 727.9 ± 906.6 km before education to 496.0 ± 732.1 km after education. This is identical with our experts’ view and shows how information and the training of anesthesiologists on the environmental impact of inhalation anesthetics alone is effective and leads to a decrease in CO\textsubscript{2}e [51].

Due to the strong media presence of sustainability and climate protection, hospital management is becoming increasingly aware of the topic. The perspectives of experts are divided into two factions. On one hand, there are those who hold some reservations about media attention, due to the fear of hospital management engaging in greenwashing. This skepticism is not unfounded, considering the growing number of reports highlighting instances of large retail chains that actively promote their products as environmentally friendly, a practice known as greenwashing. Loffreda et al. also confirm this issue in their research, demonstrating the impact of the fossil industry on the healthcare sector [52]. The second cohort of anesthesiologists finds this attention to be highly beneficial, as it engenders a sense of accountability among both the population and the hospital staff. Such accountability can serve to motivate individuals to take a more proactive role in environmental conservation and sustainability initiatives. There is one particular advantage of media attention that should not be overlooked: it can serve as an effective recruitment tool by highlighting the institution’s commitment to sustainability. This has already been demonstrated in Northern Virginia, USA, where hospitals have utilized advertising to attract new staff members [53]. Furthermore, some hospitals in Austria have embraced this approach and are actively seeking to recruit new employees.

4.7. Sustainable Practices on International Scale

Speaking of sustainable anesthesia and practices on the Austrian scale, this opens the question: what are other nations doing in this case? Various medical societies are already demonstrating their positions, by publishing guidelines on how to improve sustainable practices in healthcare. On the European scale, the French Society of Anesthesiology and Intensive Care (SFAR) recently published guidelines for reducing the environmental impact of general anesthesia, which are not different from what our experts indicate [54]. Colleagues in America examined the carbon footprint data of three hospitals from different healthcare systems (Canada, the USA, and the UK). American and Canadian hospitals have a 10-times-higher CO\textsubscript{2}e/year (2,034,277 kg CO\textsubscript{2}e/year and 2,129,841 kg CO\textsubscript{2}e/year) compared to the UK (211,212 kg CO\textsubscript{2}e/year). Emissions due to anesthetic gases made the difference, as the USA and Canada are still using Desflurane on a higher scale, compared to the UK [14].

There is a Sustainability Roadmap launched by the American Hospitals Association in cooperation with the American Society of Healthcare Engineering (ASHE), the Association for the Healthcare Environment, and the Association for Healthcare Resource and Materials Management [55]. The goal of this project is to help their members, which are more than 5000 hospitals and health systems, to take meaningful actions to improve the health of all people, by setting a sustainable practice [56]. Sustainable anesthesia is not only a nationwide topic; it is far bigger than that. Other nations are trying to set up practices and guidelines to improve sustainability. This is just a small glimpse on the international scale with, currently, a limited amount of data, but it shows how different nations deal with sustainable practices and how Austria fits into these strategies.

4.8. Practical Applicability

- Stop using Desflurane as a routine method for general anesthesia.
- Focus on waste reduction and separation in the operating theatres.
- Set a good example and spread the word of sustainable anesthesia to all other colleges in your clinic, especially to those in training.
5. Conclusions

The following conclusions were drawn from the data obtained through expert interviews. Interest in sustainability within the field of anesthesia in Austria has increased significantly over the last two years. Sustainability has increasingly become the focus of training courses and scientific congresses. Anesthetists in Austria are well-informed and continuously trained by representatives of the PNAI. The assumption that young colleagues are more interested in sustainability than older colleagues cannot be clearly proven. It depends heavily on the hospital and state in Austria. Green teams must include members of anesthesia and other clinical departments. There is no consensus among experts on the increased use of TIVAs, as this could only lead to a shift in the timing of the environmental problem in terms of waste management, and improvements need to be made, as experts know from their network that there is a deficit all over Austria.

As a recruitment measure, sustainability is becoming increasingly popular with hospital management, which has a positive effect on the environment, as it means they must establish sustainability measures at their hospitals.

Our work demonstrates that extensive measures and initiatives have already been implemented in the field of anesthesia with regard to sustainability, and further changes are ongoing. The outlook is encouraging, as a growing number of healthcare facilities are embracing, and anesthesiologists are becoming progressively more cognizant of sustainable practices. This work provides a comprehensive overview of the current state of sustainability in our field.

Author Contributions: All the authors have made a substantial, direct, and intellectual contribution to this study. Conceptualization, S.H.; methodology, S.H. and H.B.-C.; project administration, S.H.; formal analysis, H.B.-C., K.L.-I. and L.H.; investigation, S.H. and M.B.; writing—original draft preparation, S.H., H.B.-C., K.L.-I., L.H. and M.B.; writing—review and editing, S.H., H.B.-C., K.L.-I., L.H. and M.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Conflicts of Interest: The authors declare no conflicts of interest.

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