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Original study

Towards a more sustainable operating theatre: the opinions of Belgian surgeons, anesthesiolo-gists, nurses, and other operating theatre professionals

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Abstract

Background: **Hospitals generate significant amounts of waste and operating rooms (ORs) are major contributors to pollution and greenhouse gas (GHG) emissions. Segregation habits often differ significantly between homes and workplaces.**
Objectives: **This study investigated the opinions, barriers, and commitments perceived by OR professionals in Belgium to act more sustainably, focusing on waste segregation and recycling within ORs. We also surveyed the habits of anesthesiologists that influence greenhouse gas emissions.**
Methods: **We conducted a cross-sectional study using an online questionnaire targeting professionals in Belgian ORs, including anesthesiologists, surgeons, nurses, and other operating theatre staff members. The questionnaire was distributed in three languages (Dutch, French, and English), and included closed questions using Likert scales and multiple-choice questions. Statistical analysis was performed using Pearson's chi-squared and Fisher's exact tests for group comparisons.**
Results and Discussion: **Of 673 participants, nurses constituted the largest group. More than 60% of the participants had extensive experience (>10 years in OR). The vast majority segregated waste at home, but much less waste was segregated in the ORs, despite high willingness. Unlike other waste categories, hazardous medical waste is universally segregated. Papers and plastics are often treated as non-hazardous wastes. The main perceived barriers were proper waste facilities and time and space constraints, indicating that effective implementation was hampered by structural deficiencies. A sub-study showed that most anesthesiologists used sevoflurane with a low or very low fresh gas flow, contributing to lower GHG emissions. Potent GHG such as nitrous oxide and desflurane are infrequently used.**
Conclusions: **This study showed a gap between Belgian OR professionals' willingness to act sustainably and their actual implementation. Improving infrastructure and providing training and information are essential steps for promoting sustainable waste management in hospitals. These changes can lead to a more sustainable health care environment.**

Key words: **waste management, operating rooms, surveys and questionnaires, change management.**

Introduction

Everyday life generates a mix of waste types including organic, plastic, paper, glass, and hazardous materials. The appropriate segregation of these streams is essential for effective recycling and disposal. Medical facilities produce a wide range of specialized wastes, including infectious hazardous materials, pharmaceuticals, and sharps[1]. Hospitals are assumed to be responsible for over 5% of the country's waste[2,3]. Operating rooms (ORs) play a critical role in hospital-patient care. However, they also generate substantial amounts of waste, including surgical supplies, packaging, and biomedical waste, which account for at least 20-30% of the total hospital waste[4]. Within ORs, anesthesia services are particularly polluting because of significant greenhouse gas (GHG)

emissions: 5% of emissions from hospitals and 3% of total national healthcare emissions[5]. Anesthesia vapors, particularly desflurane and nitrous oxide, significantly contribute to GHG emissions. Although gas-scavenging systems are commonly used inside ORs, these gases are almost always released directly into the atmosphere, where they have high global warming potential. Reducing the use of these gases and adopting more sustainable practices in anesthesia can help mitigate their environmental impact[6]. Fresh gas flow during anesthesia significantly contributes to GHG emissions. Reducing fresh gas flow can minimize the release of these potent GHG, making anesthesia practices more sustainable.

Proper waste management within ORs is essential to minimize environmental impacts and promote sustainability. In this context, segregation and recycling practices are crucial to contribute to a greener healthcare system while maintaining patient safety. However, implementing and maintaining a successful recycling program in healthcare, particularly in the operating room, pose numerous challenges. Lack of awareness and motivation often leads to improper waste disposal[7]. Studies have shown that up to 70% of hazardous waste is non-hazardous. Healthcare professionals may not understand the impact of their choices or find it inconvenient to segregate the waste[7,8]. Some view waste segregation as a hassle. They may prioritize patient care over waste management. OR staff may not be aware of what materials can be recycled or how to properly sort and prepare recyclable materials. Additionally, the fast-paced and high-pressure environment of the operating room makes it difficult to implement segregation processes without disrupting surgical flow. Therefore, the time required for segregation may hinder the implementation of new guidelines[9].

Lack of appropriate infrastructure and equipment may also be a barrier[8]. Operating rooms often lack the necessary space and equipment to properly segregate and store recyclable materials, which makes it difficult to implement recycling programs. Furthermore, many operating rooms have limited storage areas, and there may be a lack of space to store recyclable materials before they can be properly disposed[10]. Additionally, the lack of standardization of recycling practices across different hospitals can make it difficult to implement a recycling program in the operating room. Each hospital may have different regulations, policies, and recycling procedures, which can make it challenging to develop a uniform recycling program. Infection control may also counterbalance sustainability[8]. Single-use equipment (e.g., masks and gloves) protects against infection, but contributes to waste. Sterile equipment often comes in disposable packing cloths, which affects waste volume[11]. Another challenge is legal and regulatory compliance, which forces hospitals to adhere to medical waste regulations[8]. Failure to comply can result in fines or environmental harm. Waste management also involves cost and resource constraints[7]. The implementation of efficient waste management systems requires investment, as the recycling infrastructure, education, and monitoring generate costs. Budget constraints affect waste management decisions. Reusable items may be cost-effective, but require initial investment. New medical technologies have also introduced new waste streams. Hospitals must adapt their waste management practices accordingly. By recycling materials such as paper, plastic, metals, and sterile cloths, hospitals can save on disposal costs and reduce their overall waste output. Research on the cost-benefit analysis of recycling in operating rooms is limited, but what is available suggests that recycling can provide significant cost savings for hospitals. One study that evaluated the implementation of a recycling program in an operating room found that the program resulted in cost savings of $20.000 per year, primarily because of the reduced waste disposal costs[12].

Raising awareness about waste reduction, recycling, and reuse is crucial for both society and hospitals. In Australia, New Zealand, and England, anesthesiologists participating in a survey supported OR waste recycling, while identifying barriers. They called for anesthesiologists to lead and cooperate with other OR staff members to improve OR recycling[13]. Similar initiatives have been supported in Europe, emphasizing the role of medical professionals in leading sustainability efforts within healthcare settings. Studies have highlighted the potential for significant environmental and economic benefits when recycling programs are effectively implemented in operating rooms[14-16].

Since March 15, 2023, healthcare organizations in Flanders, Belgium's northern region, have been encouraged to participate in Green Deal 013 Sustainable Care. (https://www.omgeving.vlaanderen.be/nl/013-duurzame-zorg). Green Deal aims to stimulate cooperation and facilitate the exchange of knowledge and experience. It is appealing to commit to concrete and sustainable actions adapted to one's own possibilities. All these actions, both small and large, can collectively create a positive signal and the necessary sustainable acceleration. Participation in the Green Deal involves voluntary and ambitious agreements between healthcare partners and the Flemish government to initiate sustainable projects. This implies an effort commitment, not a commitment to

obtain predefined results.

With this survey, we aimed to gauge the willingness and enthusiasm of OR staff to make the OR a more sustainable place, and poll opportunities and limitations in the segregation and recycling of waste in the OR. Simultaneously, we wanted to use the survey to sensitize healthcare staff to reflect on segregation and recycling opportunities within their own organizations and to initiate actions within their capabilities. Finally, existing potentially contaminating anesthesia habits were examined.

Methods

Study design and setting

In a 14-question survey, we assessed the attitudes of OR professionals towards the segregation and recycling of OR waste. Additionally, we posed two questions to anesthesiologists regarding anesthesia practices in the OR (Table I).

A cross-sectional study design was employed to distribute an online questionnaire via SurveyMonkey® to all eligible operating room professionals (including nurses, surgeons, anesthesiologists, logistics personnel, and others) in Belgian hospitals. The questionnaire used closed-format responses featuring Likert-type scales, multiple choice options, and one open question.

An informative email containing a direct link to the online survey was sent to the patient safety coordinators and medical directors of all Belgian hospitals with operating theatres, requesting that they forward the email to the OR professionals. A reminder email was sent after four weeks. The survey and all communication were drafted and distributed in three languages: Dutch, French, and English. A trial survey was conducted in AZ Sint-Blasius between January 15 and February 15, 2023. It was available to all Belgian hospitals from March 1 to March 31, 2023.

Questionnaire and variables

The survey comprised four parts:

Part 1: This section investigated the demographics of the participating OR staff, including professional groups (anesthesiologists, surgeons, nurses, logistics personnel, and others), years of experience in the OR (<1, >1, >5, >10, >20 years), hospital region (Flanders, Wallonia, Brussels Capital Region), hospital type (general or university hospital), and hospital size (<200 beds (small), >200 beds (medium), >500 beds (large), and >1000 beds (very large)).

Part 2: This section examined segregation habits both at home and in the OR using a five-point Likert scale (totally agree, partially agree, uncertain, partially disagree, and totally disagree). For further analysis, the responses were consolidated into three categories (agree, uncertain, and disagree). Participants were also asked about the types of waste segregated in the operating room, including hazardous medical waste, non-hazardous medical waste, paper, plastics/metals/beverage containers, glass, sterile drapes, and other materials.

Part 3: This section assessed opinions on waste segregation in the OR using a five-point Likert scale (totally agree, partially agree, uncertain, partially disagree, and totally disagree) and subsequent consolidation into three categories (agree, uncertain, and disagree). The questions included the willingness to segregate waste in the OR, perceived barriers to waste segregation (multiple choice), and the primary barrier to waste segregation (single choice). The response options for the last two questions were lack of proper recycling facilities, lack of time, lack of space, colleagues' attitudes, insufficient information, cost, safety, and none of the above options.

Table I. — Survey questions.

1. Language	Dutch | French | English
2. I am a	Nurse | Surgeon | Anesthesiologist | Operating theatre logistics officer | Other
3. Number of years' experience in OR	<1 | >1 | >5 | >10 | >20 years
4. The number of beds in my hospital is	<200 | >200 | >500 | >1000 beds
5. I work in	Flanders | Brussels | Wallonia
6. I work in a	General hospital | University hospital
7. I segregate waste at home	Strongly disagree | disagree | uncertain | agree | strongly agree
8. Waste is segregated in the ORs where I work	Strongly disagree | disagree | uncertain | agree | strongly agree
9. What we collect in our OR	Hazardous medical waste | Non-hazardous medical waste | Paper | Plastics, metals, beverage containers | Glass | Sterile drapes | Other
10. I would like to segregate waste in the operating theatre	Strongly disagree | disagree | uncertain | agree | strongly agree
11. Which ONE or MORE are barriers to waste segregation in operating theatres?	Staff attitudes | Cost | Insufficient information | Safety | Time | Lack of space | Lack of recycling facilities | None of these
12. Which of the following is the most important barrier to waste segregation? (choose one)	Staff attitudes | Cost | Insufficient information | Safety | Time | Lack of space | Lack of recycling facilities | None of these
13. To increase segregation in ORs I am willing to provide the following (select ONE or MORE)	Time to educate others | Time to educate myself | None of the above
14. Do you have any additional comments about segretation in operating theatres or about this survey?	
ONLY FOR ANESTHESIOLOGISTS	
15. The maintenance anesthetic I use commonly for anesthesia (multiple answers possible)	Sevoflurane | Desflurane | Nitrous Oxide | Propofol
16. What is the usual fresh gas flow if using vapor?	<1 | 1-3 | >3 L/min

Part 4: This section focused exclusively on anesthesiologists, comprising two questions: the commonly used maintenance anesthetic (sevoflurane, desflurane, nitrous oxide, propofol) and the average amount of fresh gas flow used during anesthesia (<1, 1-3, >3 L/min).

Participants were required to answer each question before proceeding to the next question (Table I).

Study size

Based on publications from the Federal Public Service of Health and the Flemish Agency of Care and Health, we estimated that the total number of OR staff exceeded 40,000 professionals. This included over 11,500 licensed physicians working in the OR. Given that there are approximately three nurses per doctor, as reported by the Flemish Agency, we can conclude that approximately 40,000 individuals (comprising doctors and nurses) are employed in operating rooms (https://www.health.belgium.be/nl/gezondheid/zorgberoepen/artsen-tandartsen-en-apothekers/artsen-specialisten; https://www.zorg-en-gezondheid.be/ziekenhuispersoneel; https://overlegorganen.gezondheid.belgie.be/sites/default/files/documents/statan_2023_nl). To achieve a statistically significant sample size with a 95% confidence interval and 5% margin of error, a sample size of 381 participants was required.

Bias

Response bias (participants did not provide accurate answers but instead offered perceived expected responses) was mitigated by providing anonymity, neutral questions, and clear instructions. To minimize non-response bias (individuals disinterested in environmental issues and waste segregation are likely to be less inclined to participate in the survey) and population sampling bias, all OR professionals in Belgian hospitals were invited to participate in the survey. This inclusive approach aimed to ensure a representative sample of the target population. However, a low response rate to email invitations increases the risk of non-response bias.

Statistical methods

Respondent characteristics were summarized using proportions for categorical variables. Differences in demographics and opinions were analyzed using Pearson's chi-square test or Fisher's exact test, as appropriate, with the aid of free online software (Vassar Stats®, Website for Statistical Computation) and XLSTAT (Lumivero®, 2023, https://www.xlstat.com), accessed 2023). Subgroup analyses were conducted for professional group, experience, and hospital size. Statistical significance was set at P-value < 0.01, to limit the number of false positives owing to the large number of tests conducted in this study.

Ethical considerations

This study was approved by the Medical Ethics Committee of AZ Sint-Blasius, Kroonveldlaan 50, 9200 Dendermonde (chair Dr. S. Serry), on January 4, 2023 (Reference: B0122022000010). The requirement for informed consent was waived. The survey adhered to the General Data Protection Regulation (GDPR) guidelines. Participants were explicitly informed of the confidentiality measures regarding the collected data and were assured of the anonymity of their responses. The IP addresses were promptly removed from the dataset upon completion of data segregation. No incentives were offered to complete the survey.

Results

In total, 890 OR professionals participated in the Belgian survey. After excluding 127 participants who did not complete the survey, 763 OR professionals were included in this study (Figure 1). The main results are presented in an infographic (Figure 2).

Demographics

Professional groups

The participants were classified into five professional categories. Most of the respondents were nurses (53.7%), comprising the largest group, followed by surgeons (17.2%) and anesthesiologists (16.6%). A smaller proportion of participants were involved in logistics, and a subset of respondents fell into the 'other' category, encompassing various unspecified roles. Detailed data on the distribution of professional groups are presented in Table II.

OR experience

The participants exhibited a broad spectrum of experience levels within the OR. A notable proportion of respondents had over a decade of OR experience, with a significant subset reporting more than 20 years. Conversely, a smaller fraction of participants had less than one year of experience. In addition, some participants did not disclose their experience level. We recognize the significance of differentiating between the start of training and the beginning of a career as a certified anesthesiologist. The calculation of years of experience is anchored on the onset of the traineeship, as this signifies the commencement of practical, supervised clinical work in anesthesia. This method ensures uniformity in defining practitioner experience. Subgroup

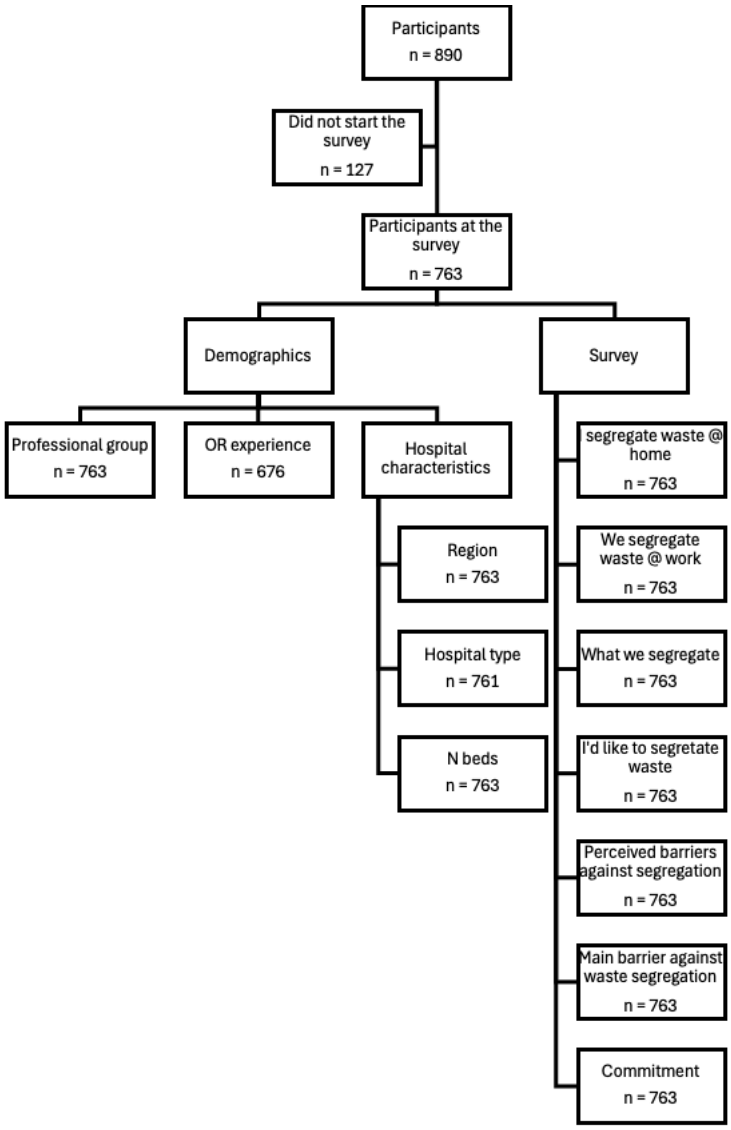

Fig. 1 — Flow diagram.

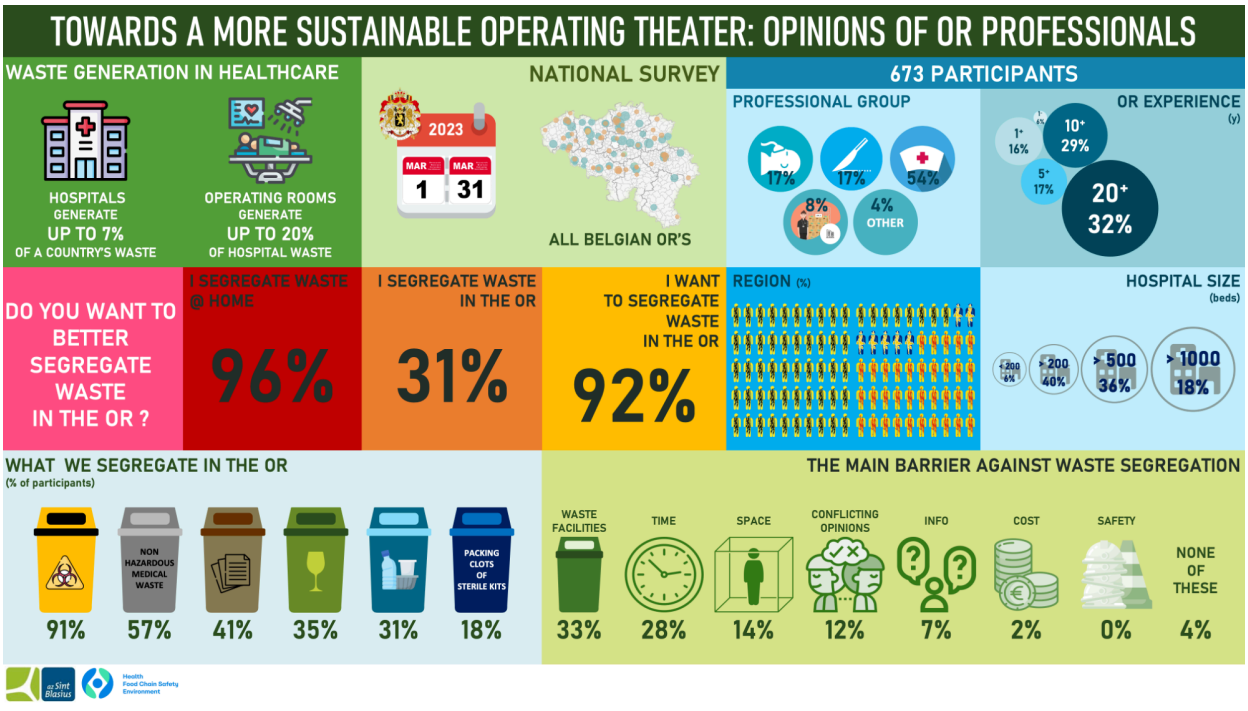

Fig. 2 — Infographic.

analyses were conducted to explore potential variations based on professional group, geographical region, and hospital size. The distributions are listed in Table II.

A statistically significant association was found between professional groups and level of OR experience ($P < 0.0001$). Specifically, OR experience was likely to be < 1y in the 'other' group. By contrast, logistics professionals were notably less likely to have > 20y of OR experience (Table II). Eighty-seven anesthesiologists failed to report their experience. Upon review, it appeared that there was a programming error in the flow of the survey, causing anesthesiologists who used the Dutch version of the survey to not be presented with this question.

Analysis of OR experience distribution across Belgium's three regions (Brussels Capital Region, Flanders, and Wallonia) showed no statistically significant differences, indicating that OR experience was evenly distributed among professionals across regions (Table II). Subgroup analysis by hospital size revealed no statistically significant differences in OR experience across hospitals of varying sizes, indicating that OR experience was consistently distributed among professionals, regardless of where they worked (Table II).

Hospital characteristics

Region

The distribution of participants perfectly reflects the geographical distribution of inhabitants in the three Belgian regions, with the majority situated in Flanders, followed by Wallonia and the Brussels Capital Region (Table II).

Hospital type

The distribution of hospital types among the participants was compared with national data from Belgian hospitals. Most respondents were from general hospitals, with a smaller proportion from university hospitals. Two responses were left blank, reducing the total number of responses to this question to 761 (Table II).

National data indicate that general hospitals constitute the majority of the hospitals in Belgium, with a smaller percentage represented by university hospitals and those with university characteristics. Additionally, 30% of these hospitals are publicly managed, while 70% are private and organized as non-profit entities [https://www.gezondbelgie.be/nl/blikvanger-gezondheidszorg/algemene-ziekenhuizen/organisatie/soorten-ziekenhuizen].

There was a statistically significant difference between our study data and national figures, indicating a higher representation of university hospital participants and a lower representation from general hospitals than expected ($P < 0.001$).

Hospital Size

The sizes of the hospitals, categorized by the number of beds, varied among participants' institutions. The majority practiced in medium-sized and large hospitals, more than in very large and small hospitals (Table II). Subgroup analysis by professional group identified a significant association between hospital size and professional group ($P = 0.005$). Fisher's exact test further revealed significant differences for surgeons in medium hospitals and anesthesiologists in very

Table II. — Demographics.

Professional groups	n = 763	
surgeon | anesthesiologist | nurse | logistics | other (%)	17.17 | 16.64 | 53.74 | 3.93 | 8.52	
OR experience (years)	n = 676; MV = 87 anesthesiologists	
<1 | >1 | >5 | >10 | >20 (%)	5.77 | 16.57 | 16.86 | 28.99 | 31.80	
SGA professional group	*logistics: less than expected >20y (P = 0.008)* *other: more than expected <1y (P < 0.0001)*	**P < 0.0001**
SGA region	*no significant differences*	P = 0.975
SGA hospital size	*no significant differences*	P = 0.274
Region	n = 763	
BXL Capital Region | Flanders | Wallonia (%)	7.21 | 58.06 | 34.73	**P = 0.006**
	BXL: less than expected; Wallonia: more than expected	
Hospital type	n = 763	
general | university hospital (%)	85.02 | 14.98	**P < 0.001**
Hospital size (beds)	n = 763	
<200 | >200 | >500 | >1000 (%)	5.90 | 39.71 | 36.44 | 17.96	
SGA professional group (n = 676, MV: 87 anesthesiologists)	*surgeons: more than expected >200 beds (P = 0.008)* *anesthesiologists: more than expected >1000 beds (P = 0.0001)*	**P = 0.005**
SGA region	*Flanders: more than expected >200 beds (P < 0.0001); less than expected <200 beds (P = 0.001); less than expected >500 beds (P < 0.0001)*	**P < 0.0001**
	Wallonia: less than expected >200 beds (P < 0.0001); more than expected <200 beds (P = 0,003), more than expected > 500 beds (P < 0.0001)	

SGA = subgroup analysis; MV = missing values; BXL: Brussels; statistical significance: P < 0.01

large hospitals, indicating distinct distribution patterns across hospital sizes (Table II). These findings underscore the variation in the professional group distribution relative to hospital size. Subgroup analysis by region revealed a significant association between hospital size and region ($P < 0.0001$). Fisher's exact test highlighted notable distribution patterns: Flanders had a higher proportion of participants in medium-sized hospitals, whereas Wallonia had a greater representation in both small and large hospitals, with fewer participants in medium-sized hospitals (Table II). These findings indicate distinct regional variations in the distribution of hospital sizes among the participants.

Segregation habits at home and in the OR

The survey results indicated a strong commitment to segregate waste at home, with 95.54% of participants stating that they engaged in this practice. A small percentage was uncertain (1.83%) or did not segregate waste (2.62%). In contrast, commitment to segregating waste in the OR was significantly lower. Only 31.06% of participants stated that they segregated waste at work, 48.89% did not segregate waste at work, and 20.05% remained uncertain. Although nearly all participants were committed to waste segregation at home, a significant barrier existed in translating this practice to the workplace (Table III).

Subgroup analysis of segregation habits at home showed no significant differences between professional groups, OR experience, or hospital size. However, domestic segregation habits were significantly less common in Wallonia ($P = 0.005$) (Table III).

Subgroup analysis of segregation habits at work revealed clear differences. Surgeons were less prone, whereas nurses and logistics workers were more prone to waste segregation ($P < 0.0001$). Waste segregation was less common in medium-sized hospitals than in extra-large hospitals ($P < 0.0001$) and more common in Flanders than in the Brussels Capital Region and Wallonia ($P < 0.0001$). There were no differences in OR experience.

Most OR professionals declared segregating hazardous (91.09%) and non-hazardous medical waste (57.14%). Paper (40.89%), plastics/metals/beverage containers (31.45%), glass (35.12%), sterile drapes (18.35%), and other waste (5.64%) were less frequently segregated. The subgroup analysis for hazardous medical waste showed no differences between regions or hospital sizes. However, for most waste categories, segregation was significantly more common in Flanders and in extra-large hospitals ($P < 0.0001$) (Table III).

Opinions on waste segregation in the OR

The willingness to segregate waste in the OR was extremely high: 91.74% of the participants expressed a clear desire to collect and recycle waste. There were no significant differences between the subgroups (Table IV).

Barriers to segregation were also commonly perceived. The lack of proper recycling facilities (32.77%) was identified as the most important barrier, followed by lack of time (28.05%) and space (13.63%). The conflicting attitudes of colleagues were identified as the main barriers by 11.80% of participants. Insufficient information (7.47%), cost (2.10%), and safety (0.39%) were considered small barriers (Table IV).

Commitment to education of waste segregation

Although willingness seemed to be high, effective commitment was somewhat lower. Among participants, 50.98% were committed to offering time to educate others. Subgroup analysis showed more commitment in the BXL Capital Region and Wallonia ($P < 0.0001$). There were no significant differences between professional groups, OR experience, or hospital size (Table V).

Of the participants, 53.34% were committed to taking time for self-education. Subgroup analysis showed less commitment among logistics workers and other OR professionals. No significant differences were observed in the OR experience, region, or hospital size (Table V).

A small proportion of participants (17.43%) showed resistance, indicating that they did not want to offer anything to change segregation habits in their OR. Resistance was lower among surgeons, higher among nurses, and more prevalent in Flanders than in Wallonia (both $P < 0.0001$). No differences in OR experience or hospital size were observed between groups (Table V).

Anesthesia practice

Sevoflurane was the most commonly used maintenance anesthetic (95.28%) before propofol (36.22%). Desflurane and nitrous oxide, which are most commonly associated with GHG emissions, were used less frequently (3.94% and 11.81%, respectively). No differences in region or hospital size were observed.

No anesthesiologist reported using a higher fresh gas flow (FGF) (> 3 L/min). Very low (< 1 L/min) and low (1-3 L/min) FGF levels were evenly distributed (Table VI).

Discussion

Climate change and pollution are major topics that concern our society today and will influence

Table III. — Segration habits.

I segregate waste at home	n = 763	
agrees | uncertain | disagrees (%)	95.54 | 1.83 | 2.62	
SGA professional group (n = 676, MV: 87 anesthesiologists)	*no significant differences*	P = 0.459
SGA experience	*no significant differences*	P = 0.241
SGA region	*Wallonia: less than expected disagree (P = 0.003)*	**P = 0.005**
SGA hospital size	*no significant differences*	P = 0.381
We segragate waste in the OR	n = 763	
agrees | uncertain | disagrees	31.06 | 20.05 | 48.89	**P < 0.0001**
SGA professional group (n = 676, MV: 87 anesthesiologists)	*Surgeons: less than expected agree (P < 0.0001); more than expected disagree (P < 0.0001)* *Nurses: less than expected disagree (P = 0.006)* *Logistics: less than expected disagree (P = 0.006)*	
SGA experience	*no significant differences*	P = 0.239
SGA region	*BXL Capital region: more than expected disagree (P = 0.005)* *Flanders: more than expected agree (P < 0.0001); less than expected disagree (P < 0.0001)* *Wallonia: less than expected agree (P = 0.002); more than expected disagree (P = 0.002)*	**P < 0.0001**
SGA hospital size	*>200 beds: less than expected agree (P < 0.0001); more than expected disagree (P < 0.0001)* *>1000 beds: more than expected agree (P < 0.0001); less than expected disagree (P < 0.0001)*	**P < 0.0001**
What we collect in our OR	n = 763	
Hazardous medical waste | Non-hazardous medical waste | Paper | Plastics, metals, beverage containers | Glass | Sterile drapes | Other (%)	91.09 | 57.14 | 40.89 | 35.12 | 18.35 | 5.64	
Hazardous medical waste		
SGA region: BXL Capital region | Flanders | Wallonia (% yes)	87.27 | 91.42 | 91.42	P = 0.587
SGA hospital size: <200 | >200 | >500 | >1000 beds (% yes)	86.68 | 92.41 | 89.21 | 93.43	P = 0.276
Non-hazardous medical waste		
SGA region: BXL Capital region | Flanders | Wallonia (% yes)	34.55 | 66.59 | 46.04	**P < 0.0001**
	BXL Capital region: less than expected (P = 0.001) *Flanders: more than expected (P < 0.0001)* *Wallonia: less than expected (P < 0.0001)*	
SGA hospital size: <200 | >200 | >500 | >1000 beds (% yes)	40.00 | 58.42 | 52.88 | 68.61	**P = 0.002**
	> 1000 beds: more than expected (P = 0.003)	
Plastics, metals, beverage containers		
SGA region: BXL Capital region | Flanders | Wallonia (% yes)	10.91 | 36.12 | 27.92	**P < 0.0001**
	BXL Capital region: less than expected (P = 0.001) *Flanders: more than expected (P < 0.0001)* *Wallonia: less than expected (P = 0.0003)*	
SGA hospital size: <200 | >200 | >500 | >1000 beds (% yes)	22.22 | 19.80 | 35.25 | 52.55	**P < 0.0001**
	>200 beds: less than expected (P < 0.0001) *>1000 beds: more than expected (P < 0.0001)*	
Paper		
SGA region: BXL Capital region | Flanders | Wallonia (% yes)	21.82 | 50.34 | 29.06	**P < 0.0001**
	BXL Capital region: less than expected (P = 0.003) *Flanders: more than expected (P < 0.0001)* *Wallonia: less than expected (P < 0.0001)*	
SGA hospital size: <200 | >200 | >500 | >1000 beds (% yes)	42.22 | 32.67 | 41.01 | 58.39	**P < 0.0001**
	>200 beds: less than expected (P = 0.0002) *>1000 beds: more than expected (P < 0.0001)*	
Glass		
SGA region: BXL Capital region | Flanders | Wallonia (% yes)	23.64 | 41.53 | 26.79	**P < 0.0001**
	Flanders: more than expected (P < 0.0001) *Wallonia: less than expected (P = 0.0005)*	
SGA hospital size: <200 | >200 | >500 | >1000 beds (% yes)	22.22 | 33.99 | 34.89 | 42.34	P = 0.086
Sterile sets packaging		
SGA region: BXL Capital region | Flanders | Wallonia (% yes)	10.91 | 23.48 | 11.32	**P < 0.0001**
	Flanders: more than expected (P < 0.0001) *Wallonia: less than expected (P = 0.0001)*	
SGA hospital size: <200 | >200 | >500 | >1000 beds (% yes)	6.67 | 11.22 | 17.27 | 40.15	**P < 0.0001**
	>200 beds: less than expected (P < 0.0001) *>1000 beds: more than expected (P < 0.0001)*	
Other		
SGA region: BXL Capital region | Flanders | Wallonia (% yes)	9.09 | 3.61 | 8.30	P = 0.011
SGA hospital size: <200 | >200 | >500 | >1000 beds (% yes)	13.3 | 3.96 | 4.68 | 8.76	P = 0.022

SGA = subgroup analysis; MV = missing values; BXL: Brussels; statistical significance: P < 0.01

Table IV. — Segration habits.

I'd like to collect | recycle waste in the OR	n = 763
agrees | uncertain | disagrees (%)	91.74 | 4.33 | 3.93
SGA professional group	P = 0.258
SGA experience	P = 0.174
SGA region	P = 0.025
SGA hospital size	P = 0.761
Perceived barriers against segregating waste in the OR	n = 763
Lack of recycling facilities (%)	63.83
Lack of time (%)	57.67
Lack of space (%)	55.83
Attitude of colleagues (%)	44.04
Insufficient information (%)	37.88
Cost (%)	10.75
Safety (%)	5.50
None of these (%)	3.67
The main barrier against recycling waste	n = 763
Lack of recycling facilities (%)	32.77
Lack of time (%)	28.05
Lack of space (%)	13.63
Attitude of colleagues (%)	11.80
Insufficient information (%)	7.47
Cost (%)	2.10
Safety (%)	0.39
None of these (%)	3.8

SGA = subgroup analysis; MV = missing values; BXL: Brussels; statistical significance: P < 0.01

Table V. — Commitment to education of waste segration.

I'm willing to offer time to educate others	**Yes: n = 389 (50.98%)**	
SGA professional group: surgeon | anesthesiologist | nurse | logistics | other (% yes)	47.33 | 42.52 | 51.71 | 53.33 | 69.23	P = 0.011
SGA experience: <1 | >1 | >5 | >10 | >20y (% yes)	56.41 | 49.11 | 56.14 | 55.10 | 51.63	P = 0.771
SGA region: BXL Capital region | Flanders | Wallonia (% yes)	69.09 | 42.89 | 60.75	**P < 0.0001**
	BXL Capital region more than expected (P = 0.007); Flanders less than expected (P < 0.0001); Wallonia more than expected (P = 0.0001)	
SGA hospital size: <200 | >200 | >500 | >1000 beds (% yes)	55.56 | 48.84 | 53.24 | 49.64	P = 0.660
I'm willing to offer time to educate myself	**Yes: n = 407 (53.34%)**	
SGA professional group: surgeon | anesthesiologist | nurse | logistics | other (% yes)	61.07 | 59.84 | 52.93 | 30.00 | 38.46	**P = 0.001**
	Trend for logistics (P = 0,014) and other (P = 0,013)	
SGA experience: <1 | >1 | >5 | >10 | >20y (% yes) (MV = 87 anesthesiologists)	46.15 | 57.14 | 57.89 | 57.14 | 44.66	P = 0.042
SGA region: BXL Capital region | Flanders | Wallonia (% yes)	50.91 | 49.89 | 59.62	P = 0.040
SGA hospital size: <200 | >200 | >500 | >1000 beds (% yes)	53.33 | 56.11 | 53.96 | 45.99	P = 0.267
I offer nothing	**Yes: n = 133 (17.43%)**	
SGA professional group: surgeon | anesthesiologist | nurse | logistics | other (% yes)	4.58 | 20.47 | 20.73 | 36.67 | 7.69	**P < 0.0001**
	Surgeons less than expected (P < 0.0001), nurses more than expected (P = 0,010)	
SGA experience: <1 | >1 | >5 | >10 | >20y (% yes) (MV = 87 anesthesiologists)	15.38 | 19.64 | 15.31 | 16.74 | 14.04	P = 0.819
SGA region: BXL Capital region | Flanders | Wallonia (% yes)	10.91 | 22.80 | 9.81	**P < 0.0001**
	Flanders more than expected (P < 0.0001), Wallonia less than expected (P < 0.0001)	
SGA hospital size: <200 | >200 | >500 | >1000 beds (% yes)	8.89 | 15.84 | 17.27 | 24.09	P = 0.071

SGA = subgroup analysis; MV = missing values; BXL: Brussels; statistical significance: P < 0.01

the lives and deaths of present and subsequent generations. Healthcare facilities currently face a dual challenge: an increase in medical waste generation and an increasing need for waste segregation. Unfortunately, much of this waste is inadequately segregated, resulting in disposal via incineration[1]. This practice leads to widespread pollution across extensive areas, posing significant health risks to many individuals. Fortunately, change is on the way, as there is growing awareness among hospital professionals that hospitals and ORs need to better segregate and recycle their waste.

This survey was the first on the European continent to explore the opinions of OR professionals regarding waste segregation in their professional environment. The questionnaire was partially derived from a previous study that surveyed anesthesiologists in Australia, New Zealand, and the United Kingdom[13]. Similar to the findings of this study, our research confirmed a notable distinction in waste segregation behaviors between home and work environments. While individuals often practice responsible waste management at home, hospitals frequently lack effective systems for proper medical waste disposal, highlighting the stark contrast between personal environmental consciousness and institutional practices in healthcare settings. The observed disparity highlights the necessity

for enhanced waste management protocols within healthcare institutions to better align with individual environmental practices. The implementation of comprehensive waste segregation systems in hospitals can substantially mitigate the environmental impact of medical waste. The development and execution of education and training programs for healthcare professionals focusing on proper waste segregation techniques, particularly for non-hazardous medical waste, could effectively address the discrepancy between personal and institutional waste management practices[17].

Second, the vast majority of OR professionals segregate hazardous medical waste, but only a few segregate non-hazardous medical waste, such as plastics or packing cloths of sterile sets, which account for the largest volume and can be easily segregated. By implementing comprehensive waste segregation protocols that include non-hazardous medical waste, healthcare facilities can substantially reduce their environmental impact and potentially lower disposal cost[18-20]. Implementing a non-hazardous medical waste segregation initiative in our hospital's OR required the immediate restructuring of the container storage area. The space allocated for sorting plastics expanded to twice its original size, whereas the area designated for other non-hazardous residual waste was reduced by half. Given the substantially reduced costs associated with the storage and collection of this waste, this might represent a significant financial improvement for the hospital.

To the opinion of OR professionals, the absence of appropriate waste segregation facilities was the main barrier to waste segregation. This finding has also been confirmed in other studies[21]. The lack of proper infrastructure and collection systems makes it difficult for individuals to effectively segregate their waste. Hence, employees simply do not segregate waste. At our hospital, all ORs are now equipped with assigned waste bins for plastics, packing cloths of sterile sets, and paper. This decision proved essential in encouraging doctors and nurses to better segregate waste. Education and training programs for OR staff, coupled with clear signage and easily accessible segregation bins, could promote more effective waste management practices across all types of medical wastes.

Although insufficient time and space for waste segregation were cited as significant obstacles, their impact may have been exaggerated. Our initial assessment revealed that proper segregation does not require additional time. The issue of limited time and space might be relevant in smaller facilities or in those with poor design, creating opportunities for design improvement[21,22].

As in the study by McGain et al., willingness to segregate waste was very high[13]. Nevertheless, a significant difference was observed between willingness and commitment. A significant number of people show resistance to change or lack the drive to pursue self-improvement or to share knowledge with others. This tendency was particularly noticeable among staff with lower levels of responsibility and education. Ownership, beliefs about consequences, social influence/role/identity, and beliefs about individual capabilities may have influenced commitment[9,23].

Finally, anesthesia services continue to contribute to significant GHG emissions. Professional guidelines recommend against the use of the most potent GHG, nitrous oxide and desflurane[24,25]. In our survey, the use of nitrous oxide and desflurane was limited; however, it remains important. Some anesthesiologists find it difficult to stop nitrous oxide use, particularly during pediatric anesthesia. Sevoflurane and propofol were used more commonly according to the survey. The choice should weigh the contributions of the former to GHG emissions against the ecotoxicity to water and soil of the latter. All anesthesiologists in our survey stated the use of low or very low fresh gas flow, thereby contributing to lower GHG emissions.

Limitations

Despite our efforts to minimize bias, the possibility of some remaining bias cannot be eliminated. One potential source is non-response bias, where employees who are more environmentally conscious in their workplace behavior may have been more inclined to participate in the study than those who are indifferent to such concerns. Additionally, 87 anesthesiologists did not respond in the section "OR experience," which could lead to an under- or over-estimation of the results related to that section, further contributing to non-response bias.

The European Global Data Protection Ruling prevents access to the individual email addresses of all the OR staff. Therefore, we relied on the managers' goodwill. Some hospital managers declined to distribute the survey to their staff, often without clear explanation. This may have introduced sampling bias. Furthermore, undercoverage bias may have occurred, as certain groups, such as logistics staff, might not have been adequately represented in the survey responses.

Nevertheless, subgroup analyses indicated that the study participants accurately represented the diverse professional groups working in the OR. Fortunately, we achieved the target sample size to make valid conclusions.

We based our survey on the McGains survey, replicating its questions in the same sequence, but then broadened the scope to include various types of waste13. This approach may have led to some confusion among OR professionals about whether they segregated waste in the OR and the specific types of waste that were segregated. Only 31.06% of respondents indicated that they segregated waste in the OR. However, 91.09% answered affirmatively to the subsequent question about segregating hazardous waste, and 57.14% did so for non-hazardous waste. In fact, the required segregation of hazardous and non-hazardous waste is already a form of segregation. Participants likely compared their home waste management practices to those in the OR, considering which materials, such as paper, metal, plastics, and glass, could be excluded from non-hazardous waste.

Generalizability

Subgroup analysis revealed distinct regional variations in the responses to multiple questions. This highlights disparities in environmental consciousness across Belgium. The government of Flanders has invested more time and resources in teaching its citizens proper waste sorting and recycling methods compared with other regions. This may have affected the generalizability of our results.

Conclusion

This study highlights a significant gap between personal and professional waste management practices among Belgian OR professionals. While the majority of OR staff are willing to engage in sustainable practices, inadequate infrastructure and recycling systems in hospitals are major barriers. Addressing these issues through education, better infrastructure, and leadership from healthcare professionals can improve waste segregation and recycling. By prioritizing non-hazardous medical waste segregation, hospitals can significantly reduce environmental impacts and costs, marking a crucial step towards a more sustainable healthcare system.

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