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ORIGINAL RESEARCH

Kickstarting the Adoption Process of Reusable Surgical Gowns in Healthcare: Expectations, Evaluation and Factors That May Influence Healthcare Professional's Willingness to Wear Reusable Gowns

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Purpose: Health organizations play a critical role in society, but they also contribute significantly to global carbon emissions. This study examines the adoption of reusable surgical gowns to reduce operating room waste and emissions.

Methods: Two surveys ($n_A = 146$ and $n_B = 55$) and a pilot test in two Belgian university hospitals (Antwerp and Ghent) are conducted to assess operating room healthcare professionals' (HCP) willingness to reuse (adoption intention), and how expectations and evaluation can influence the adoption of reusable gowns. A between-subject design compared perceptions of HCP without recent experience with reusable gowns (HCP A) and participants in a wearing test (HCP B).

Results: It was found that participants of the pilot test had greater adoption intention than HCP without recent experience. Moreover, HCP with higher expectations about reusable gowns were also more willing to adopt. Misconceptions about reusable gowns being old-fashioned or inferior were common among those unwilling to adopt. Currently, HCP have lower expectations about reusable gowns compared to the disposables in use, in terms of trust in protection, comfort and usability. However, participants of the pilot test evaluated their trust in protective properties higher than what HCP without wearing the gown had initially expected.

Conclusion: Information campaigns on reusables in healthcare and educational insights on their safe use can improve perceptions about reusable gowns as a safe and high-quality alternative. This study's findings may guide legislative efforts and hospital managers to promote sustainable healthcare practices. Fostering bottom-up readiness among HCPs may influence the hospital's procurement process. Additionally, further improving the design of reusable products can optimize the user satisfaction.

Plain Language Summary: Hospitals and other healthcare organizations are important for our well-being, but they also create a lot of waste. One way to reduce this waste is by using reusable products, like surgical gowns. This study looked at how healthcare professionals feel about using reusable surgical gowns. The researchers: 1) Asked healthcare professionals in the operating room to fill out a survey; 2) Carried out a wearing test where healthcare professionals wore reusable surgical gowns during their shift; 3) Asked the participants of the wearing test to fill out a survey.

Here is what they found:

- People who wore the gowns were more likely to want to use them again.
- If healthcare professionals expected the gowns to be comfortable and protective, they were more open to using them.
- Some people who had not tried reusable gowns thought they were old-fashioned or not as good.
- After trying them, many healthcare professionals trusted the gowns more than they expected to.

Sharing clear information and giving people the chance to try reusable gowns can help change opinions. Better design of reusable products can also make them more comfortable and easier to use. These steps can support a shift toward more sustainable choices in healthcare.

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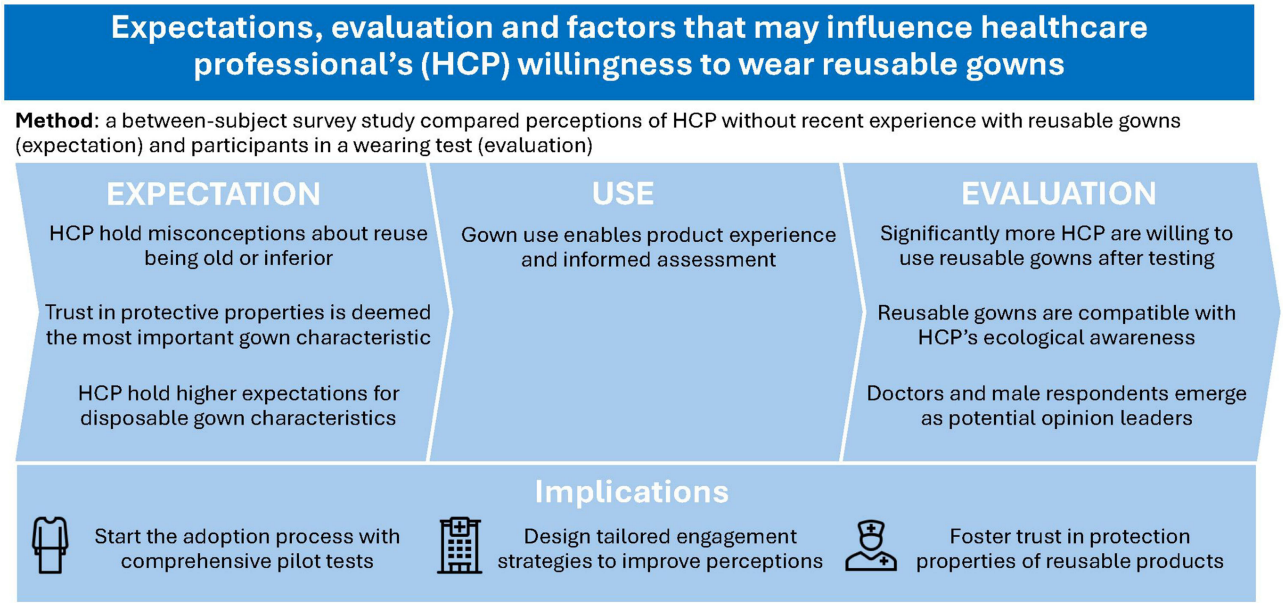
Graphical Abstract



Keywords: survey research, adoption process, trialability, reusable surgical gowns, reusable products, circular economy

Introduction

In a 2019 international study of healthcare carbon footprints, the healthcare sector is hold responsible for 1.6 Gt of CO2 or 4.4% of the global total in 2014 (35.7 Gt).[1] Meanwhile, the Lancet Climate Change Commission declared climate change "the biggest global health threat of the 21st century" due to its adverse health impacts.[2] To break this cycle, it is essential to focus on sustainability initiatives within healthcare.[3] One crucial action in this regard is the reduction of waste generated during healthcare delivery.[4–6] In recent years, hospitals have predominantly relied on disposable medical products for sterile applications, especially during the outbreak of COVID-19.[7–10] The operating room (OR) is a significant area of interest, as it substantially contributes to a hospital's footprint through its high levels of waste production, energy consumption, and emissions of anesthetic gases.[11] Disposable medical textiles, such as surgical gowns, towels, and drapes, contribute significantly to operating room waste.[12] The circular economy emphasizes maximizing product utility and designing for longevity.[13] Despite the existence of reusable alternatives, disposables remain dominant, highlighting the need to optimize reusable medical textiles for extended use. Herweyers[14] identified design strategies for long-term reuse by analyzing motivators and barriers from a product, context, and user (PCU) perspective.[15] As product durability, available infrastructure, decision-making routines, and user characteristics (egoccupation and task) all influence the adoption process and market penetration of reusable medical textiles in the healthcare sector.

Attributes That Enhance Behavior Intention and Adoption

The transition to sustainable healthcare practices can be understood through Rogers' Diffusion of Innovation (DOI) Theory.[16,17] This theory explains how innovations spread through social systems over time, with individuals following an innovation-decision process. Rogers identifies five key attributes that influence 49% to 87% of adoption variance in the persuasion stage: (i) relative advantage over current practices (RA), (ii) compatibility with existing values and needs (C), (iii) simplicity of use (S), (iv) trialability (ease of experimentation) (T), and (v) visibility of results (V).[18] More recent research indicates that Rogers' five innovation attributes significantly impact the adoption of sustainability innovations

and evidence-based practices in healthcare.[19–21] For instance, Yap et al[12] researched expectations about product performance and found that healthcare professionals (HCPs) hesitated to adopt reusable surgical gowns due to concerns about their effectiveness. An important performance indicator for innovative healthcare products is perceived quality. Perceived product quality is influenced by quality cues, which provide information before use.[22] In the context of healthcare, supporting products such as hospital gowns should be easy to use and not hindering the complex medical interventions, they should preferable be compatible with the routines HCP is trained for.[23]

Trialability, or the ability to test an innovation, enhances adoption likelihood.[24] Jilani et al[25] demonstrated that trialability significantly increases users' intention to adopt mHealth apps. Similarly, visibility—especially when respected clinicians advocate for an innovation—fosters peer discussions and accelerates adoption.[17] Opinion leaders, as defined by Rogers,[16] play a crucial role in influencing their peers' willingness to adopt new practices.[26]

Aakko and Niinimäki's[22] contextual map of quality perception highlights how product assessment evolves. Initial expectations (quality cues), shaped by intrinsic and extrinsic cues, are refined through user experience.[27,28] While their model assumes post-purchase assessment, HCPs lack direct purchasing authority. Pilot testing enables HCPs to engage with products firsthand, facilitating informed evaluation and alignment with practical needs.

Indeed, although HCPs are part of a broader social system, each undergoes an individual decision-making process regarding innovation adoption. In healthcare organizations, formal procurement decisions are often complex[29] and ideally involve input from multiple stakeholders, including HCPs.[30] Their acceptance and demand can drive institutional shifts toward reusable alternatives, making HCP's perceptions and willingness to reuse critical factors in the successful adoption of sustainable practices.[31] Moreover, hospital administrators and purchasing departments increasingly require evidence-based insights to inform cost-benefit analyses.[32] The development of policy and governmental guidelines typically follows the establishment of robust empirical evidence. Consequently, the findings of this study may serve as a foundation for shaping legislative initiatives that promote sustainable healthcare practices.[33]

The Product Perspective for Sterile Surgical Gowns

A surgical gown's function serves a dual purpose: protecting the patient by maintaining a sterile barrier to prevent contamination, as well as protecting the wearer from exposure to blood, bodily fluids, and potential infections.[34–36] According to the European Medical Device legislation[37] and the harmonized standard EN13795 for surgical clothing and drapes,[38] sterile surgical gowns are Medical Devices[39] that are qualified to protect the patient. The protective function of surgical gowns remains unchanged, whether they are disposable or reusable. However, their intrinsic product characteristics vary depending on the brand, product type, and model available on the market. These characteristics—such as wearing comfort, ease of use, trust in protection, and sustainability—play a significant role in a hospital's purchasing decisions and can be influenced by design.[12,35,40]

Comparative studies of reusable and disposable sterile surgical gowns highlight the environmental advantages of reusable options, showing a potential reduction of 66% in greenhouse gas emissions and 84% in solid waste generation.[41] A survey-based study with 80 OR staff members in gynecology compared the comfort and usability of both gown types. The results showed that over 79% of participants rated reusable gowns as equal to or better than disposable ones in terms of ventilation, fit, functionality (standing, sitting, walking), barrier performance, and ease of use.[42] Additionally, a review by Bolten et al[43] assessing the carbon footprint of OR infection prevention found no evidence that reusable and disposable instruments, gowns, and drapes differ in their effectiveness in preventing surgical site infections. Furthermore, McQuerry et al[40] suggest that reusable gowns may offer enhanced protection and significant cost savings due to their superior durability and sustainability compared to disposable alternatives.

The Context Perspective for Hospital Purchasing Processes

The context of a hospital, and particularly the OR, is highly specialized. Strict hygiene standards are essential, but the ability to act swiftly and without obstruction is equally crucial. Reusable surgical gowns, like disposables, are available in individual or set packaging and must remain readily accessible. After use, however, reusable gowns are collected for laundering, this can either be on-site or by an external provider.[44] The laundering process involves

washing, rinsing and drying with detergents and rinse agents to ensure proper decontamination.[41] Steam sterilization is the most commonly recommended method by manufacturers, typically requiring exposure to 121–135°C for 3–30 minutes, followed by a drying cycle of 1–30 minutes. Additionally, the hospital context necessitates specific procurement procedures, relying on the input of diverse stakeholders.[30,35,40] To ensure an informed decision, a hospital purchasing manager performs thorough analyses before implementing a new practice:[32,45] safety regulations, financial considerations, logistic feasibility, market availability, and ensured delivery are important (extrinsic) context factors.

The User Perspective for Healthcare Professionals

OR personnel, including surgeons and nurses, are key informants on gown suitability. Ideally, products are tested, feedback is gathered, and HCPs advocate for items that enhance performance and efficiency. Yap et al[12] identified that most perioperative staff believes reusable surgical gowns are environmentally friendly. Nevertheless, ambivalence towards transitioning to reusable gowns stemmed from uncertainty in reusable textiles' safety profile, cost savings, and environmental benefits. These perceptions may prevent successful actual implementation of reusable surgical gowns. One factor that may counter distrust and uncertainty is the observable benefits and successful adoption of a reusable gowns by relevant others. Therefore, identifying innovators and early adopters in the introduction of reusable gowns is key to promoting wider adoption among the early majority, late majority, and laggards.[46] Personal characteristics, such as occupation, gender, and age, influence HCPs' willingness to adopt sustainable practices. Research shows that women and younger individuals are more inclined toward environmentally friendly choices.[47,48] Additionally, occupation (doctor vs nurse) and years of employment significantly impact gown preferences.[30] Those already engaged in pro-environmental behavior are also more likely to adopt sustainable alternatives.[49]

Research Gap

Research underscores the advantages of reusable gowns over disposables in comfort, usability, protection, and sustainability. Despite HCPs' interest in sustainability, awareness and experience with reusable alternatives remain limited. Hospitals also require evidence-based guidance for procurement and policy decisions. This study applies the PCU perspective to understand HCPs' adoption intention of reusable surgical gowns in a high-risk environment, addressing the understudied factors influencing adoption. Additionally, knowledge gaps persist regarding preferred product characteristics, and the role of innovative users and early adopters in influencing hospital decision-making remains unexplored.

Aim & Research Questions

Drawing on the DOI theory[16] and the contextual framework of quality perception,[22,28] this study aims to explore and describe the factors that influence HCPs' adoption of reusable surgical gowns. The innovation attributes proposed by the DOI theory (RA, C, S, T, and V) are integrated with perceived quality components to examine how specific gown characteristics and contextual hospital factors shape adoption intention. These theoretical constructs are mapped conceptually in Figure 1.

First, we assess the expectations of HCPs who have not used reusable gowns (non-users). Second, we investigate the impact of trialability and visibility by analyzing feedback from participants in a pilot test with reusable gowns. This research is guided by three key questions in line with the PCU perspective.

RQ1 (product): What do HCPs expect of reusable surgical gowns and how do they evaluate the use of reusable surgical gowns in the operating room?

- What is the importance of surgical gown characteristics in terms of comfort, usability, trust in protection and sustainability according to HCP?
- What are HCP's initial expectations of reusable surgical gown performance in terms of comfort, usability, trust in protection and sustainability for non-users?

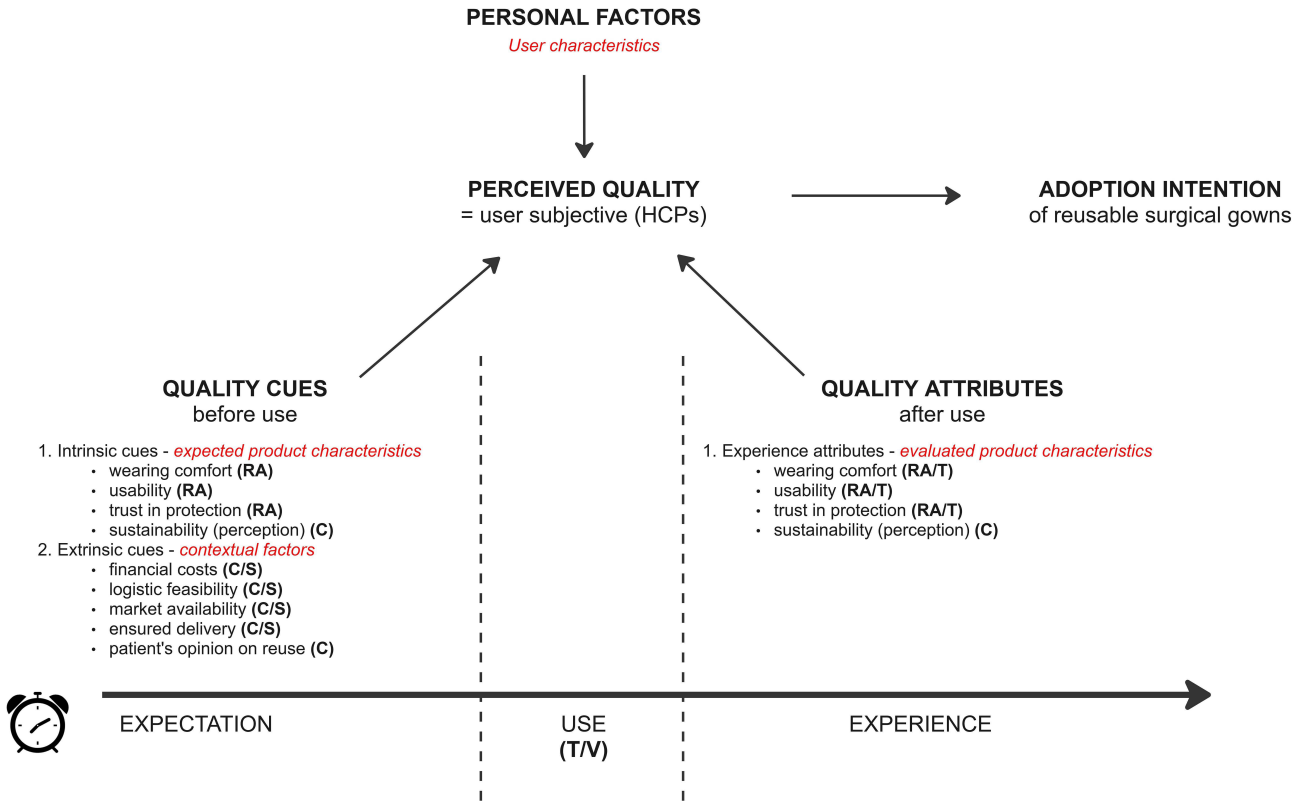


Figure 1 Conceptual model integrating DOI attributes and perceived quality components in the context of reusable surgical gown adoption.
Abbreviations: HCPs, healthcare professionals; RA, relative advantage; C, compatibility; S, simplicity; T, trialability; V, visibility.

- How do these expectations relate to disposable surgical gown performance expectations ?
- How do the initial expectations of non-users align with the actual evaluations of reusable gowns pilot test participants?

RQ2 (context): Which context factors (financial, logistic, availability, delivery and patient opinion) have an influence on the adoption process of reusable surgical gowns according to HCP?
RQ3 (user): Which user profiles can be considered as possible early adopters of reusable gowns?

- Are there differences in expectations towards reusable gowns characteristics between HCP with different user characteristics (occupation, gender, age, ecological concern, work experience)?
- Does adoption intention of the reusable surgical gown differ between HCP that tried out the gown compared to HCP that did not try out the gown?
- Are there differences in adoption intention of reusable surgical gowns between HCP with different user characteristics (occupation, age, gender, ecological concern and prior experiences)?
- How does expected gown performance (comfort, usability, trust in protection and sustainability) relate HCP's (un) willingness to use reusable gowns?

Materials and Methods

Figure 2 shows how we plan to achieve insights on the HCPs' PCU-perceptions of reusable surgical gowns. As not to bias insights in expectation and evaluation, eg through priming mechanisms or awareness creation, the present study utilizes a between subject design.[50]

One group (HCP A) is surveyed on their expectations (expectation survey) regarding the characteristics of reusable surgical gowns, while another group (HCP B) evaluates (evaluation survey) the same characteristics after participating in a pilot test. Both groups indicate their willingness to adopt reusable gowns in the future. Given the anticipated larger sample size of HCP A, this group will also respond to additional questions assessing their concerns related to the context factors of the procurement process of reusable surgical gowns.

Methods

The expectation survey was distributed, using the snowball sampling technique, to healthcare professionals with experience in working in the operating room in Belgium (HCP A). The researcher contacted OR supervisors by telephone. If the supervisors agreed to participate in the research, they forwarded an e-mail-invitation with hyperlink to their personnel. 22 Supervisors and 2 professional OR associations (for OR nurses and medical specialists) agreed to distribute the survey link via e-mail. The mail contained an online survey link (programmed in Qualtrics, Provo, UT, USA) that was available from the 6th of October 2022 to the 20th of December 2022. The evaluation survey was distributed to a smaller sample, only participants in a pilot test with reusable surgical gowns (HCP B) were allow to

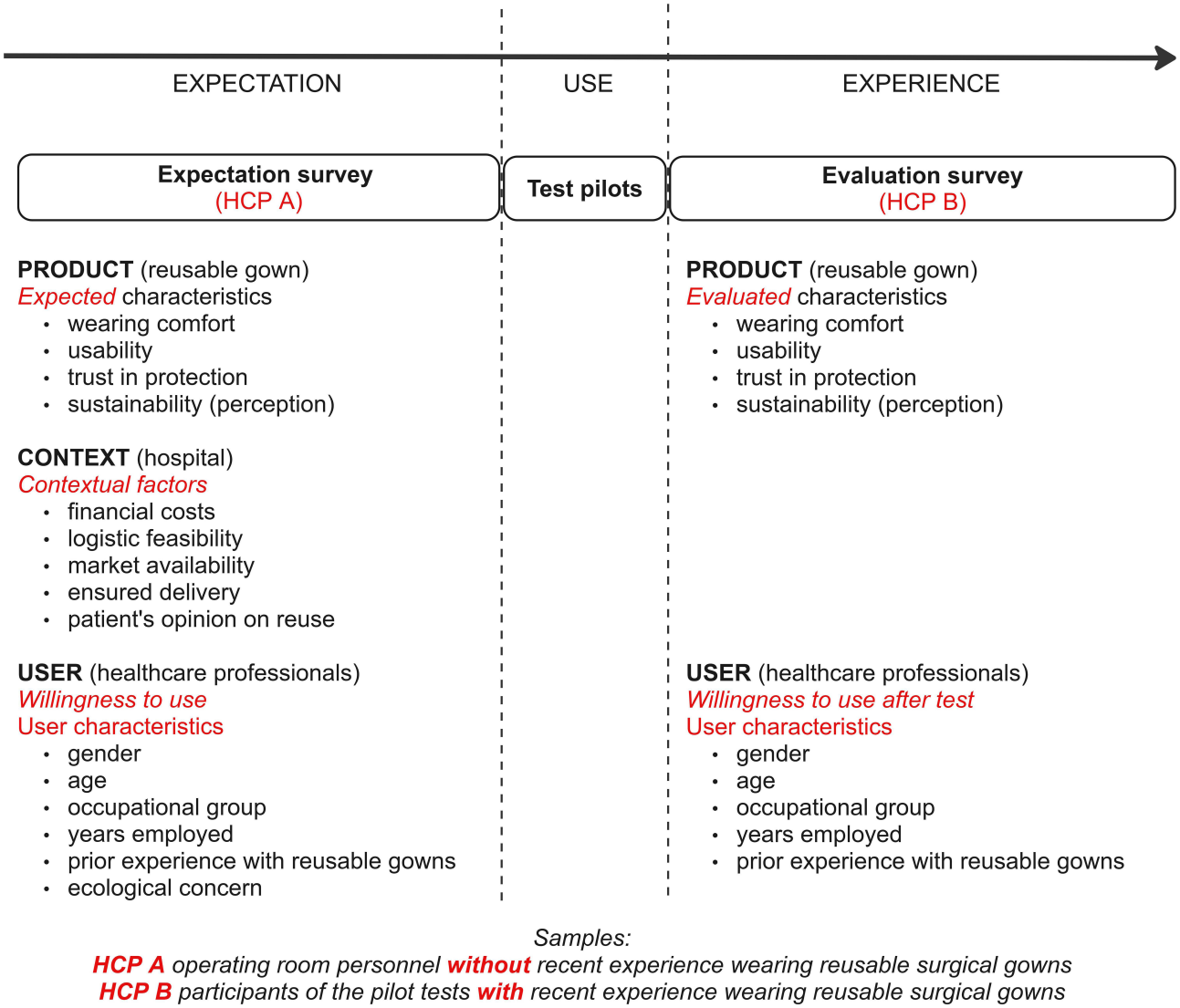


Figure 2 Overview of the methods and measures used in the between subject design of this study.
Abbreviation: HCP, healthcare professionals in group A or B.

participate. The pilot tests took place in two Flemish university hospitals (Antwerp and Ghent). Each test took a time span of one week (5 working days) and consisted of one day with the hospital's regular disposable surgical gowns and four days observation with reusable surgical gowns. The time span was determined in consideration of practical feasibility and availability of the gown supplier. To maximize the variety of disciplines in our sample, each day of observation, one operating room was randomly selected for the pilot test. Two weeks prior to the test, surgeons and nurses were informed about the study's objectives and provided consent for both observation and survey participation. During the pilot tests, a researcher was present in the operating room to ensure proper use and collection of the reusable gowns. Staff members could revert to disposable gowns if they experienced discomfort. The pilot test encompassed a variety of surgical procedures, including open, laparoscopic, endoscopic, external, minor, and robot-assisted surgeries. Participants represented a broad range of disciplines, such as abdominal surgery, gynaecology, orthopaedics and traumatology, urology, plastic surgery, thoracic and vascular surgery, neurosurgery, ear, nose, and throat, paediatric surgery, oral and maxillofacial surgery, transplant and hepatobiliary surgery, ophthalmology, and cardiac surgery. This wide representation limited the feasibility of discipline-specific statistical analyses. Following the pilot test, participants (HCP B) received an online survey link to evaluate the reusable gowns. The survey remained open from November 21 to December 20, 2022. This study received ethical approval from the Ethics Committee for Social Sciences & Humanities at the University of Antwerp.

Measures

The survey was developed based on the PCU perspectives outlined by Herweyers[14] and the five innovation attributes from the DOI theory of Rogers.[16] While previous studies have applied DOI constructs in healthcare,[51–53] none specifically address the operational context of the OR through surveying. To accommodate this time-sensitive and high-pressure environment, single-item measures were used to minimize respondent burden and optimize completion.[54] This approach is considered appropriate for applied research where the aim is to explore associations rather than develop a psychometric scale.[55,56] The items were designed to assess how gown characteristics, hospital context, and user demographics relate to healthcare professionals' intentions to adopt reusable surgical gowns.

The willingness to reuse a surgical gown (dependent variable): to assess the behavioral intention[57] of HCP A and B, respondents had to indicate their willingness to reuse a surgical gown in both contexts. Responses were captured using a close-ended question with three options: yes, no, or not sure. To deepen our understanding of these responses, we applied methodological triangulation by integrating qualitative data, allowing for richer interpretation of the underlying motivations.[58] If respondents indicated "no" a branch question would appear on the next survey-page to ask for a motivation why they were not inclined to use a reusable alternative of this product.

Willingness to reuse other medical textile products: Similarly, respondents in both conditions were asked to indicate their willingness to use a reusable alternative for six types of medical textile products: sterile surgical drape, surgical hairnet, surgical mouth mask, warmth jacket (worn by OR personnel), warmth blanket (for patients), and an absorbent pad.

Gown characteristics (product): The study explores four gown characteristics: Usability refers to handling ease, including how easy it is to unpack it, how easy it is to do on and off, how easy it is to dispose it in the correct bin, wearing comfort includes thermal comfort and fit, trust in the protective properties of reusable surgical gowns, and perceived sustainability of these gowns. To assess the gown characteristics, we build on scales used to predict adoption intention and user acceptance.[59,60] Respondents (HCP A) rated the importance of each characteristic item in the expectation survey, using a 5-point Likert scale (1 = not important at all; 2 = not important; 3 = neutral; 4 = important; 5 = very important).[61,62] They also scored characteristics (1 = not good at all; 2 = not good; 3 = neutral; 4 = good; 5 = very good) of their current disposable gowns and characteristic expectations for reusable gown. In the evaluation survey, respondents (HCP B) rated the same characteristics, only for the reusable gowns they had worn during the pilot test.

Factors of influence (context): Likewise, respondents in the expectation survey (HCP A) rated the importance of contextual elements for the adoption intention: financial cost, logistic feasibility, market availability, delivery assurance, and patient opinion on a 5-point Likert scale.

User characteristics: As for user profiles, close-ended questions were included in both surveys: gender, age, occupational group, work experience and prior experience with reusable gowns. If respondents indicated to have prior experience with reusable gowns, a branch question would appear on the next survey-page to ask for a brief context description and their opinion about the use of reusable surgical gowns. For HPC A, additional information was recorded: the frequency of gown use and environmental concern was measured by using the NEP scale consisting of fifteen items, five point Likert scales with a Cronbach's alpha of 0.742.[63]

Statistical Analysis

The analyses were performed using IBM SPSS Statistics (Version 28.0; IBM Corp., Endicott, New York, United States). Crosstabs with Chi², paired and independent sample T-tests, and ANOVAS with Bonferroni *T*-test were used to differentiate significant differences between user groups. P-values less than .01 were considered statistically significant. For the open questions in the survey (unwillingness and prior experience) a qualitative analysis was conducted. Answers were listed in an Excel file (Version 16.0, Microsoft Corp., Redmond, Washington, United States) and open and axial coding was done to identify meaningful themes in participant responses.

Results

For both surveys, the data were cleaned, and incomplete responses were removed from the dataset. The expectation survey (HCP A) yielded 146 fully completed responses, achieving a 63% completion rate.

For the evaluation survey, 124 participants from the pilot test (HCP B) were invited, resulting in 68 completed responses, a 55% response rate and an 87% completion rate. Among these pilot test participants, 13 had worn a disposable gown, while 55 had worn a reusable gown during the test. Only the evaluation responses of the 55 reusable gown wearers will be used in this result section.

Sample Description

Table 1 gives an overview of the respondents' characteristics. Occupational groups include nurses (scrub nurses, circulating nurses, anesthesia nurses), doctors (surgeons and anesthetists), and others (OR manager, OR coordinator, OR logistics). Of the doctors in HCP A, 35 are surgeon (of which 9 specialists in training), 12 are anesthetist (of which 4 specialists in training) and one is a trainee doctor. Accordingly, the doctors in HCP B, 21 are surgeons (of which 9 specialists in training) and 5 are anesthetists (of which 4 specialists in training). No significant differences between the samples' demographics were observed.

Regarding ecological concern (n = 146), the majority of respondents (97.9%) scored above 3.5 on the NEP scale, indicating a high level of ecological awareness.

Gown usage frequency among respondents from the expectation survey (HCP A) who wear sterile surgical gowns in the OR (n = 110) varied: 8.2% wore them once a week or less, 21.8% wore them 2–3 days per week, 23.6% wore them 4 days per week, and the majority (40.9%) used them 5 days per week. Only 5.5% reported wearing gowns more than 5 days per week.

On days when respondents wore sterile surgical gowns, they remained in sterile attire for an average of 5.94 hours. They used an average of 3.76 gowns per day (SD = 2.09), with usage ranging from 1 to 10 gowns per day. This corresponds to an average wear time of approximately 1 hour and 35 minutes per gown.

Regarding gown size, most respondents (46.4%) wore extra-large gowns (150 cm length), followed by 35.5% wearing large (130 cm length). A smaller proportion (10.0%) required extra-extra-large (170 cm length), while 3.6% reported wearing other sizes, and 4.5% were unsure of their gown size.

To better understand prior experience with reusable surgical gowns, two open-ended questions were included, addressing the context of use and personal opinions. Responses from both HCP A and HCP B were combined. Most reported experiences with reusable gowns dated back to the past (ranging from the 1980s to 2015), with many respondents indicating that their use occurred during foreign missions or internships in developing countries (eg South Africa, Tanzania, Uganda). Two main types of gowns were frequently mentioned: cotton reusable gowns and parachute-

Table 1 User Characteristics of the Survey Respondents

User Characteristics	Expectations Survey HCP A	Evaluation Survey HCP B	Chi²-test p-value
Gender	**n = 146**	**n = 53**	
Male	54 (37.0%)	23 (43.4%)	0.412
Female	92 (63.0%)	30 (56.6%)	
Other	0 (0.0%)	0 (0.0%)	
Age	**n = 146**	**n = 53**	
< 30 years	30 (20.5%)	20 (37.7%)	0.032
30–39 years	48 (32.9%)	18 (34.0%)	
40–49 years	37 (25.3%)	10 (18.9%)	
50–59 years	25 (17.1%)	2 (3.8%)	
>/= 60 years	6 (4.1%)	3 (5.7%)	
Occupational group	**n = 146**	**n = 53**	
Nurse	89 (61.0%)	22 (41,5%)	0.050
Doctor	47 (32.2%)	26 (49,1%)	
Other	10 (6.8%)	5 (9.4%)	
Work experience in years	**n = 146**	**n = 53**	
Less than 1 year	7 (4.8%)	8 (15.1%)	0.013
Between 1 and 10 years	57 (39.0%)	27 (50.9%)	
Between 11 and 20 years	46 (31.5%)	11 (20.8%)	
More than 20 years	36 (24.7%)	7 (13.2%)	
Prior experience	**n = 110**	**n = 50**	
Yes	60 (54.5%)	26 (52.0%)	0.746
No	49 (44.5%)	24 (48.0%)	
I do not know	1 (0.9%)	0 (0.0%)	

Notes: p-values in bold with * indicate significant values.
Abbreviation: HCP, healthcare professionals in group A or B.

like plastic gowns. While many respondents reported positive experiences regarding comfort and usability, common concerns included issues with permeability, excessive warmth, discomfort, improper sizing, and gown weight.

Test Pilot

During the eight-day pilot test, a total of 89 reusable sterile surgical gowns (standard performance, size medium, 150 cm in length) were used. Based on the average weight of disposable gowns typically used in the hospital, the pilot prevented approximately 16.4 kilograms of waste, excluding packaging.

Expected and Evaluated Gown Characteristics (RQ 1)

HCP A rated the importance of the four gown characteristics in the expectation survey. On a 5-point Likert scale, trust in protective properties was deemed the most important, with an average score of 4.68 (SD: 0.61). This was followed by wearing comfort (4.58; SD: 0.68) and usability (4.44; SD: 0.64). Although sustainability was rated the least important, it still received an average score of 4.10 (SD: 0.79), indicating that respondents also consider sustainability an important characteristic of the gown.

In the expectation survey, HCP A evaluated the characteristics of disposable gowns currently in use (n = 110) alongside their anticipated performance ratings for reusable gowns across the same four characteristics (Table 2). A paired-sample *t*-test revealed a statistically significant difference in ratings between the disposable gown characteristics and the expectation ratings for reusable gowns. Disposable gowns were rated higher in terms of trust in protective properties, wearing comfort, and usability. In contrast, reusable surgical gowns were anticipated to offer superior sustainability performance.

Table 2 Score for Disposable Surgical Gown Characteristics and Expectation for Reusable Gown Characteristics for HCP A (n = 110). Characteristics are Arranged from Most Important (Top) to Less Important (Bottom)

Gown Characteristics					
	Score of Current Disposable Gown		Expectation Reusable Gown		Paired Samples *t*-test
	Mean	SD	Mean	SD	p-value
Trust in protection	4.24	0.690	3.53	1.047	**<0.001***
Wearing comfort	4.05	0.696	3.61	0.978	**<0.001***
Usability	4.29	0.668	3.72	0.920	**<0.001***
Sustainability	2.45	1.162	3.95	0.850	**<0.001***

Notes: p-values in bold with * indicate significant values.
Abbreviation: SD, standard deviation.

Looking into user characteristics, an independent samples *t*-test revealed a significant difference (p = 0.01) in expected gown performance between female and male HCP A for trust in protection. Female respondents have lower expectations (mean: 3.33; SD: 1.038) for trust in the protective properties of a reusable surgical gown than male (mean: 3.85; SD: 0.989). No significant differences in reusable gown expectations were found for occupation, age, and work experience.

In the evaluation survey, participants from the pilot test with reusable gowns (HCP B) rated the characteristics of a reusable gown based on their recent experience during the test. Table 3 presents both the expectation and evaluation scores. On average, scores for trust in protection, usability, and sustainability were higher in the evaluation survey (HCP B) than those reported in the expectation survey (HCP A). However, an independent-samples t-test indicates that only the score for trust in protection is significantly higher. Due to the difference in sample size, a power analysis ($\alpha = 0.05$) was calculated for the independent samples t-test. Only for trust in protection a power of 0.8 was obtained.

Context Factors of Influence (RQ 2)

In the expectation survey, HCP A (n = 146) was presented with five factors that could potentially influence their own and, more critically, the hospital's decision on whether to adopt reusable surgical gowns. These factors, ranked by importance from highest to lowest, were: ensured delivery (mean = 4.32, sd = 0.885), logistical feasibility (mean = 4.07, sd = 0.876), market availability (mean = 4.00, sd = 0.752), financial cost (mean = 3.90, sd = 0.881), and patient opinion regarding reusable gowns (mean = 2.29, sd = 1.037). No significant differences were found for gender, age, occupation, work experience, ecological concerns or prior experience.

Table 3 Expected (HCP A) vs Evaluated (HCP B) Gown Characteristics for Reusable Gowns. Characteristics are Arranged from Most Important (Top) to Less Important (Bottom)

Gown Characteristics					
	Expectation Reusable Gown		Evaluation Reusable Gown		Independent Samples *t*-test
	HCP A (n = 110)		HCP B (n = 39)		
	Mean	SD	Mean	SD	p-value
Trust in protection	3.53	1.047	3.95	0.724	**0.007***
Wearing comfort	3.61	0.978	3.46	0.822	0.401
Usability	3.72	0.920	3.97	0.668	0.067
Sustainability	3.95	0.850	4.23	0.706	0.071

Notes: p-values in bold with * indicate significant values.
Abbreviations: HCP, healthcare professionals in group A or B; SD, standard deviation.

Willingness to Reuse Medical Textile Products (RQ 3)

Willingness to use reusable alternatives was assessed for both HCP A and HCP B. In the expectation survey, HCP A showed the highest willingness for reusable warmth jackets, followed by blankets, surgical caps, sterile surgical gowns and drapes. Respondents were more uncertain about absorbent pads and reusable mouth masks. In the evaluation survey, HCP B participants who had worn reusable surgical gowns showed a similar order in willingness to reuse. Table 4 displays willingness to reuse for both groups, with a Chi²-test indicating that HCP B was significantly more willing ($p < 0.01$) to use a reusable surgical gown than HCP A.

To assess differences in intention to reuse medical textile products (yes vs no) between doctors and nurses, the sample (HCP A) was limited to these occupations. Crosstab analysis (Table 5) shows that doctors are significantly more willing ($p < 0.01$) to use reusable warmth blankets. No significant differences were found based on gender, age, work experience, ecological concerns, or prior experience with reusable gowns.

To assess differences in intention to reuse a surgical gown (yes vs no) between high and low expectations, the sample (HCP A) was split in two groups. Expectations are scored on a 5-point Likert scale, scores 1 to 3 are classified as low and 4 to 5 are classified as high expectations. Crosstab analysis (Table 6) shows that for all gown characteristics, HCP with high expectations are significantly more willing ($p < 0.01$) to use reusable surgical gowns.

Discussion

Healthcare organizations play a crucial role in society but significantly contribute to global carbon emissions. Reusable surgical gowns can help reduce operating room waste and emissions. This study examines their adoption process through two surveys and a pilot test. The research explores factors that may influence the adoption of reusable surgical gowns, drawing upon the DOI's attributes to describe how gown characteristics (product), hospital factors (context) and HCPs' personal factors (user) shape adoption behavior. Specifically, the pilot test was designed to allow HCPs to experience reusable surgical gowns firsthand, simulating the innovation attributes trialalibity and visibility.

Table 4 Frequency and Percentages of Willingness to Use Reusable Alternative in the Expectation Survey (HCP A) and Participants That Wore a Reusable Gown During the Pilot Test (HCPB)

Are You Willing to Use a Reusable Alternative for a … ?	Yes	No	Unsure	Chi²-test p-value
Warmth jacket (staff)				0.604
HCP A Expectation survey (n = 146)	138 (94.5%)	4 (2.7%)	4 (2.7%)	
HCP B Evaluation survey (n = 55)	50 (90.9%)	2 (3.6%)	3 (5.5%)	
Warmth blanket (patient)				0.879
HCP A Expectation survey (n = 146)	126 (86.3%)	15 (10.3%)	5 (3.4%)	
HCP B Evaluation survey (n = 55)	46 (83.6%)	7 (12.7%)	2 (3.6%)	
Surgical cap				0.342
HCP A Expectation survey (n = 146)	122 (83.6%)	21 (14.4%)	3 (2.1%)	
HCP B Evaluation survey (n = 55)	41 (74.5%)	12 (21.8%)	2 (3.6%)	
Sterile surgical gown				**<0.001***
HCP A Expectation survey (n = 146)	91 (62.3%)	46 (31.5%)	9 (6.2%)	
HCP B Evaluation survey (n = 55)	48 (87.3%)	2 (3.6%)	5 (9.1%)	
Sterile surgical drape				0.058
HCP A Expectation survey (n = 146)	79 (54.1%)	51 (34.9%)	16 (11.0%)	
HCP B Evaluation survey (n = 55)	21 (38.2%)	22 (40.0%)	12 (21.8%)	
Absorbent pads				0.525
HCP A Expectation survey (n = 146)	64 (43.8%)	65 (44.5%)	17 (11.6%)	
HCP B Evaluation survey (n = 55)	20 (36.4%)	26 (47.3%)	9 (16.4%)	
Mouth mask				
HCP A Expectation survey (n = 146)	45 (30.8%)	88 (60.3%)	13 (8.9%)	0.013
HCP B Evaluation survey (n = 55)	6 (10.9%)	44 (80.0%)	5 (9.1%)	

Notes: p-values in bold with * indicate significant values.
Abbreviation: HCP, healthcare professionals in group A or B.

Table 5 Crosstabs of Willingness to Reuse (Yes vs No) and Occupation (Doctor vs Nurse) for HCP A

Are You Willing to Use a Reusable Alternative for a … ?	Occupation	Yes	No	p-value chi² test
Warmth jacket (staff)	Surgeon (n = 44)	44 (100%)	0 (0.0%)	0.215
	Nurse (n = 88)	85 (96.6%)	3 (3.4%)	
Warmth blanket (patient)	Surgeon (n = 46)	46 (100.0%)	0 (0.0%)	**0.005***
	Nurse (n = 86)	73 (84.9%)	13 (15.1%)	
Surgical cap	Surgeon (n = 46)	41 (89.1%)	4 (10.9%)	0.648
	Nurse (n = 88)	76 (86.4%)	12 (13.6%)	
Sterile surgical gown	Surgeon (n = 43)	35 (81.4%)	8 (18.6%)	0.015
	Nurse (n = 85)	51 (60.0%)	34 (40.0%)	
Sterile surgical drape	Surgeon (n = 42)	32 (76.2%)	10 (23.8%)	0.016
	Nurse (n = 80)	43 (53.8%)	37 (46.3%)	
Absorbent pads	Surgeon (n = 40)	25 (62.5%)	15 (37.5%)	0.053
	Nurse (n = 80)	35 (43.8%)	45 (56.3%)	
Mouth mask	Surgeon (n = 43)	17 (39.5%)	26 (60.5%)	0.223
	Nurse (n = 80)	23 (28.70%)	57 (71.3%)	

Notes: p-values in bold with * indicate significant values.

Table 6 Crosstabs of Willingness to Reuse (Yes vs No) and Expected Scores (Low (1–3) vs High (4–5)) for HCP A

Expectation	Low/High	Yes	No	p-value chi² test
Trust in protection	Low (n = 40)	18 (44.0%)	22 (55.0%)	**<0.001***
	High (n = 64)	53 (82.8%)	11 (17.2%)	
Wearing comfort	Low (n = 36)	12 (33.3%)	24 (66.7%)	**<0.001***
	High (n = 68)	59 (86.8%)	9 (13.2%)	
Usability	Low (n = 34)	13 (38.2%)	21 (61.8%)	**<0.001***
	High (n = 70)	58 (82.9%)	12 (17.1%)	
Sustainability	Low (n = 20)	8 (40.0%)	12 (60.0%)	**0.003***
	High (n = 84)	63 (75.0%)	21 (25.0%)	

Notes: p-values in bold with * indicate significant values.

Product

In this study, relative advantage as an adoption precedent does not emerge for reusable gowns. HCP's expectations regarding trust in protection, comfort, and usability were significantly lower compared to the current disposable alternative. Consequently, differences in willingness to adopt reusable gowns between HCP A and HCP B are more likely driven by user experiences during the pilot test rather than perceived relative advantages. This low perceived relative advantages for reusable gown could be related to strong repetition-based expectations as the use of surgical gowns is a vital part of the operation routine. According to a study by Verplanken and Wood[64] habit formation complicates adoption as it reduces the sensitivity to incentives in the regular performance environment, limit the user's search towards behavioral alternatives and tend to have a confirmation bias about their habitual routine. All these elements maintain the exiting behavior pattern.

Consistent with Lin & Bautista,[24] a pilot test or trialability with reusable gowns enables firsthand experience, potentially fostering greater adoption of reusable gowns. While this study is not a before and after comparison, the findings align with the DOI theory, suggesting that trialability facilitates adoption. Through the acquired experience, HCP were able to accurately assess the reusable gowns, leading to a more positive evaluation, while the adoption intention of the other products remained unchanged, HCP B displayed significant higher willingness to use reusable gowns. HCP B

also reported a significantly higher evaluation of trust in the protection of a reusable gown compared to what was expected by HCP A.

Context

HCPs prioritize ensured delivery, logistical feasibility, market availability, and financial cost as key purchasing factors. In contrast, patient opinions on reusable surgical gowns are considered relatively unimportant. This difference likely stems from the fact that supply chain and cost factors directly impact HCPs' daily operations,[65,66] whereas patient preferences do not influence the purchasing and reprocessing process.

This aligns with the innovation attributes of complexity and compatibility, where ease of integration into existing workflows is crucial.[20,67] While patient perceptions contribute to how society evaluates hospital quality and performance, HCPs argue that patients should trust healthcare organizations to ensure high-quality care in equipment-related decisions. Conversely, patient involvement is valued for treatment related decisions.[68] However, it has widely been discussed in literature that HCPs and patients have different perceptions of care quality.[69,70]

In the context of a healthcare organization, HCPs' preferences can drive institutional shifts, but the formal decision power is embedded in procedures as defined by hospital management. In the benefit of fluent adoption of innovations, hospital managers should encourage their institutions to pursue significantly more rapid-cycle tests of change across various healthcare processes, with the aim of making continuous improvement the norm.[26,29]

User

Responses to the ecological concern statements reveal that the sample (HCP A) is highly ecologically aware. According to the DOI theory, the compatibility of sustainable alternatives with their values may lead to greater openness to pilot testing.

In our sample (HCP A), doctors were generally more willing to reuse medical textile products, however, only for the patient blanket this difference was significant. This suggests that doctors may be considered opinion leaders in the adoption process. Hospital management and professional associations are recommended to take a more proactive role in identifying and supporting existing social networks, as well as the opinion leaders within them to facilitate the spread of innovations.[26] For example, providing protected time for staff at all levels to network, explore for ideas, and test new ways of working. Additionally, male respondents had significantly higher expectations for trust in the protection of reusable gowns than female respondents. This confidence may also position males more likely to be early adopters, as trust can reduce uncertainty and encourage willingness to reuse. This finding may interfere with previous research in other contexts that found female and younger individuals are more inclined toward environmentally friendly choices.[47,48]

Over 50% of respondents (HCP A and B) had prior experience with reusable surgical gowns. However, the majority of this experience dates back to before 2000 or during foreign stays, often in development countries. Unfortunately, often involving low-quality gowns (eg cotton gowns), creating the misconception that reusable gowns are old-fashioned or inferior. Consistent with literature,[42] reusable gowns are perceived less advantageous, particularly in terms of comfort. To counter this outdated perception, modern, reusable gowns and their reprocessing facilities should be actively showcased, for example, though product testing in the working environment. Additionally, when split into two groups, HCP A who had higher expectations regarding gown characteristics, also demonstrated greater willingness to reuse gowns. Highlighting the importance of raising expectations, for example, through targeted communication campaigns or testimonials. Messages describing what other people are doing (norm-based interventions) are widely used and shown to be effective to encourage certain pro-environmental behavior.[71]

Adoption of Other Medical Textile Products

Respondents (HCP A) showed the highest willingness towards using reusable alternatives for textile products such as jackets, blankets, and surgical caps. Familiarity with these types of products commonly washed and reused in the home environment may explain high willingness. The willingness to reuse *sterile* textile products, such as gowns and drapes, was notably lower. Hesitancy towards changes involving sterile products probably stem for the associated infection and safety risks. Sterility is typically perceived as ensured by using single-use items,[72] and HCP are trained to avoid risks;

when in doubt, they take a new (single-use) product. An even smaller willingness is observed for products like absorbent pads and mouth masks. Concerns about hygiene during the washing process were particularly noted for absorbent pads. HCP express concerns about the hygiene of products that have absorbed bodily fluids like blood and urine during the washing process. Additionally, the reluctance to use reusable mouth masks stems from the perception that ensuring personal hygiene is challenging due to the mask covering the mouth and nose, where breath, saliva, and makeup residues may accumulate.[73] A personal item would be preferred. In the sample with participants of the pilot test (HCP B), a similar order emerged, only the willingness to adopt reusable gowns was significantly higher.

Practical Implications

To support the transition towards reusables in healthcare, three practical implications arise from the current study. First, start the adoption process with comprehensive pilot tests. The outdated perception of reusable gowns as inferior highlights the need for more rigorous pilot testing. Willingness to use sterile surgical gowns improved significantly after pilot testing, while willingness to use other reusable alternatives that were not tested, remained the same. Suggesting that tests are helpful to ensure confidence in specific product performance and quality across various reusable items. For example, a pilot test was used to evaluate reusable stainless steel vaginal specula, resulting in overall positive attitude of clinicians[74] and in another study, computer simulations of process change ideas to improve patient-flow, accelerated adoption, primarily by enabling experimentation and demonstrating trialability.[53] Secondly, foster trust in protection properties of reusable products: participants who had participated the pilot test rated their trust in protection significantly higher than those without participation. Doubts related to safety perception of reusable medical textiles are a known barrier.[30] Female respondents, however, reported lower trust expectations compared to males. In a literature review,[47] the authors conclude that males indeed tend to have better knowledge about green issues than females. To bridge this knowledge gap, targeted educational campaigns addressing these concerns could help increase adoption.[75] Additionally, healthcare education should consider to include safe use of reusables. Lastly, tailored engagement strategies: respondents with better expectations, also reported higher adoption willingness. Campaigns to encourage adoption should highlight reusable products as safe and qualitative alternative for disposables. They can be focused on female HCP as they indicated to have lower expectations and nurses who showed lower willingness to use reusable alternatives. Badawy et al[76] propose educational and engagement messages to be conveyed via platforms such as social media to inspire HCPs and the broader public. For example in the form of videos, testimonials, and demonstrations to bridge knowledge gaps and align reusable alternatives with HCP's existing values and needs.

Limitations and Future Research

This study has following limitations: (i) The expectation survey for HCP A used snowball sampling, which may have led to reduced chance of participation, and a possible ecologically biased sample. (ii) The study relies on self-reported data, which can be inaccurate or biased. (iii) For the purpose of this exploratory study and the time-restricted target group of OR-staff, single-item measures can be methodologically appropriate and scientifically defensible.[54] Nevertheless, further validation would be valuable. For example, a test-retest reliability assessment could be conducted, particularly since the user beliefs examined in this study are expected to remain relatively stable over time.[77] Additionally, developing a validated single-item scale could enhance content and construct validity, as well as improve predictive power.[56] (iv) Due to practical constraints, a before-and-after survey was not feasible, a between-subjects comparison was conducted between HCP A and HCP B. The unequal sample sizes reflect the real-world limitations of engaging medical staff, whose time and availability are limited. While the study's exploratory and descriptive nature allowed for valuable observations, the results cannot be directly attributed to participation in the pilot. Measuring perception changes is necessary to connect pilot test participation with changes in reusable product assessments. We suspect HCP B's responses reflect recent gown experience, while HCP A's responses likely rely on past experiences or shared information.

Future research should employ a within-subjects design to assess the impact of pilot tests on reusable products, particularly for hesitant HCPs. This involves surveying staff expectations before and after a pilot test, using an anonymous linking ID for direct comparison. Furthermore, respondents who expressed uncertainty about reusables represent a target group requiring additional attention. Based on the study's findings, this group likely includes nurses and

female HCPs. Additionally, research should support pilot programs to increase familiarity and trialability, with proper test protocols and information dissemination. Further studies are needed to optimize reusable products from a technical perspective, focusing on cleaning and robustness, design attractiveness, and additional functionalities like smart textiles for communication or monitoring. In the healthcare sector, patients are evolving into "clients", heightening the need to understand patient opinions on the environmental impacts of healthcare delivery and the use of reusable products.

Conclusion

Our study, involving two surveys and a pilot test with reusable surgical gowns, highlights the importance of trialability and visibility in influencing healthcare professionals' (HCPs) adoption intentions. Participants in the pilot test had a significant higher willingness to use reusable gowns, with 87% of HCPs willing to adopt after the test. Male respondents and doctors appeared more inclined in their responses, showing higher confidence in the gowns' protective properties and adoption intentions, which may suggest their potential role as opinion leaders, while female respondents and nurses required additional convincing. Opinion leaders can drive the diffusion by advocating for reusable products. The findings point to the possible value of bottom-up readiness strategies and indicate that targeted information and educational insights may be explored to address trust-related concerns and enhance perceptions of reusable gowns as safe and high-quality alternatives. Bottom-up readiness among HCPs can trigger the procurement process, while collaboration with local companies or Work Integration Social Enterprises (WISE) can support the integration and reprocessing of reusable gowns, ultimately improving user satisfaction and driving adoption.

Abbreviations

HCP, Healthcare professional; OR, Operating room; DOI, Diffusion of Innovation; PCU, Product, context, and user; RQ, Research question.

Data Sharing Statement

All data relevant to the analysis are included in the article. The datasets generated during and/or analyzed during the current study are available upon reasonable request to the corresponding author.

Ethical Approval and Information Consent

This study received ethical clearance from the Ethics Committee for Social Sciences & Humanities of the University of Antwerp (SHW_2022_27_1) on October 4, 2022. The participants were informed about the study and written informed consent was obtained before participation in the survey.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

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