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Operationalizing circularity in healthcare: Rethinking single-use for sustainable practice

Sofia Lingegård[1], Johannes Matschewsky[2], Thomas Budde Christensen[3], Nikoline Oturai[4] and Kristian Syberg[4]

[1]Department of Sustainable Development, Environmental Science and Engineering (SEED), KTH, Sweden; [2]Department of Management and Engineering, Linköping University, Sweden; [3]Department of People and Technology, Roskilde University, Denmark and [4]Department of Science and Environment, Roskilde University, Denmark

Research Article

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Corresponding author:
Sofia Lingegård;
Email: sofia.lingegard@abe.kth.se

Abstract

The healthcare sector is a major consumer of plastics, with single-use gloves among the most frequently used items. Their use has increased significantly over recent decades, with the COVID-19 pandemic further accelerating this trend. Despite this, little is known about the drivers of glove consumption or how it might be reduced. This study examines the use of single-use plastic gloves in healthcare settings in two Scandinavian countries, drawing on interviews with 26 respondents, observational data, and document analysis. Findings reveal substantial overuse, misuse, and unnecessary disposal driven by behavioral norms, institutional practices, procurement routines, and product design. The study examines how circular strategies (R-strategies) can be applied to enhance the effective and efficient use of gloves, emphasizing the often-overlooked importance of the use phase. Behavioral change among staff emerges as more impactful than top-down policy alone, underscoring a gap between strategic goals and daily practices. The article identifies key opportunities and barriers to implementing circular solutions, offering insights relevant to researchers, healthcare professionals, procurement officers, and policymakers. Immediate practical implications center on adjusting staff routines and incentives, while further research is needed into mechanisms bridging the gap between environmental targets and medical professionals' everyday decision-making.

Impact statement

The transition to a circular economy is viewed as a key component of the movement toward a more sustainable society, as it aims to ensure that production, consumption, use and disposal occur with lower resource consumption and reduced environmental impact. However, many proposed circular solutions fail to bring about real change because the gap between theory and practice is not sufficiently illuminated. This study addresses this critical gap by examining the drivers of single-use nonsterile glove consumption in healthcare and exploring how circular strategies can reduce plastic use in practice. Focusing on hospitals and elderly care in two Scandinavian countries, the findings highlight that the use phase, where frontline healthcare staff make real-time decisions, holds the greatest potential for reducing plastic consumption, far more than procurement or recycling interventions alone. By applying a circular economy lens to the use of single-use gloves, this research provides actionable insights into how circular strategies can be implemented in complex, highly regulated public systems. The paper also explores practical barriers to reducing material consumption. This case is particularly compelling because it represents substantial and varied material use, while also offering insights that extend beyond the immediate context. These findings are broadly applicable across the healthcare sector, especially for other single-use items with low end-of-life recycling value, such as aprons and incontinence products. The study contributes to advancing circularity in healthcare by reframing how and where circular strategies can be most effectively implemented. It supports policymakers, procurement officers, healthcare managers and healthcare staff in designing interventions that go beyond recycling, encouraging systemic changes in behavior and institutional routines. In this way, the study offers valuable and novel insights to help close the knowledge gap between theoretical understanding and practical approaches to transitioning toward a more circular healthcare sector.

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Introduction

The healthcare sector is both critical to societal well-being and a significant contributor to environmental impacts. At large, healthcare systems contribute with 4.4% of the global total CO_2 emissions (Pichler et al., 2019), while simultaneously generating significant volumes of solid

waste amounting to an annual 100 million tons (Wyssusek et al., 2019; van Boerdonk et al., 2021). In Sweden alone, the healthcare sector generates ~3 million t CO_2e annually, with 20% of this, about 600,000 tons, attributed to the consumption of materials, such as gloves, tubes and single-use textiles (Teghammar et al., 2019). Single-use plastics account for 25% of the waste generated from hospitals (Gibbens, 2019), of which the vast majority is incinerated, despite 85% of it being nonhazardous (Word Health Organization, 2018).

Nonsterile single-use examination gloves, called single-use gloves in this study, constitute a substantial part of the waste generated by single-use plastics and are among the leading consumables in the total plastic consumption in healthcare (Ivanović et al., 2022). Criticism of their extensive and ever-growing use has been raised in prior research (Rizan et al., 2020; Rizan et al., 2022), with an observation study finding 42% of glove use to be inappropriate (Loveday et al., 2014). Still, existing research has primarily approached glove use from an infection control perspective and is based mainly on data collected in the United Kingdom. While the commentary by Rizan et al. (2020) broadly mentions the impacts of plastic use and the potential of implementing circular strategies, there is a lack of empirical evidence and practical guidance on how to implement such approaches within public healthcare systems. One recent study, however, underpins the need for involvement of healthcare practitioners for the implementation of circular initiatives that are effective in practice (Oturai et al., 2025). Research on circularity within the public sector at an organizational level is nascent, and investigations at different governmental levels, such as regional, are imperative (Klein et al., 2022).

Currently, only a small fraction of single-use plastics in healthcare are recycled (Joseph et al., 2021), primarily due to hygiene risks, spatial constraints and logistical barriers. These end-of-life challenges make upstream interventions, focused on reducing use and improving efficiency, especially critical. While circular strategies – R-Strategies – (Potting et al., 2017) are widely heralded as viable approaches to maintaining resource value, their operationalization in the use phase, particularly in healthcare, remains underexplored.

The current study addresses this gap by investigating the drivers of glove overconsumption and identifying how circular strategies can be applied to reduce the consumption of single-use plastics in healthcare. Grounded in empirical research across two Scandinavian countries, including workshops and interviews with healthcare professionals, the study examines glove consumption practices in hospitals and elderly care settings. It adopts a user-focused lens to understand how product use behaviors, institutional routines and procurement systems interact to drive plastic waste, and how these can be reshaped using circular approaches (derived from the 9R strategies). The article specifically aims to answer the following research questions:

RQ1: What are the main driving forces behind the increased consumption of plastic gloves?

RQ2: How could circular strategies contribute to a reduction in plastic glove consumption?

RQ3: What are the main barriers to the implementation of circular strategies for plastic glove consumption?

By focusing on the use phase, where real-time decisions about plastic consumption are made, this research provides novel insights into implementing circular economy principles in complex, highly regulated environments. Single-use gloves are used here as a case to examine broader trends in healthcare's growing reliance on single-use products and as an indicative example of this overall trend. More broadly, this study refines the application of circular economy theory by illustrating how R-strategies must be tailored to specific life cycle phases, particularly for products with low end-of-life recovery value.

Background

The EU policy and the 9R framework

The large volumes of single-use plastics consumed significantly contribute to the public sector's environmental impact. However, as public procurement accounts for 14% of the European Union's (EU's) GDP (European Court of Auditors, 2023), it wields a substantial influence on public spending toward more sustainable and circular alternatives (European Commission, 2008b; Witjes and Lozano, 2016). The EU action plan for a circular economy specifically mentions plastics as a main target area (European Commission, 2015). The strategy's primary focus is on recycled content, biodegradable materials and waste reduction measures, while decreasing consumption is not a mentioned strategy (The European Parliament and the Council, 2019). The policy context thus lacks clear incentives to reduce single-use plastic consumption.

Different strategies have been introduced to support the reduction of resource and material consumption throughout the value chain. Since its introduction by Potting et al. (2017), the circular strategies framework has been highly impactful, refined (Blomsma et al., 2019; Kurilova-Palisaitiene et al., 2023) and applied to a wide variety of products (Alamerew et al., 2020; Kambanou et al., 2024). Circular strategies range from end-of-pipe focused efforts, such as energy recovery and recycling, to entirely rethinking value creation through new ways of satisfying customers or avoiding the production and use of a product altogether. Altogether, the circular strategies framework suggested by Potting et al. (2017) covers nine strategies. In policy, the 4R framework has been deployed by the EU since the adoption of the European Commission's Community Strategy for Waste Management (European Commission, 1989) as the so-called waste hierarchy and the adoption of the waste framework directive in 2008 (European Commission, 2008a). According to Potting et al. (2017), the nine strategies can be grouped into three main categories:

- 0R Refuse, 1R Rethink and R2 Reduce are associated with smarter product use and manufacturing.
- R3 Reuse, R4 Repair, R5 Refurbish, R6 Remanufacture and R7 Repurpose are associated with the durability and lifespan of products and their parts.
- R8 Recycling and R9 Recover are associated with traditional waste management practices focusing on the application of waste materials.

The R-framework is generally regarded in academic literature as a practical way of operationalizing the circular economy into applicable strategies (Diaz et al., 2021). Circular solutions require customer acceptance, and several behavioral aspects provide barriers, such as customer understanding and knowledge of the product, impact on everyday life, quality, risks and benefits derived from solutions (Camacho-Otero et al., 2018; Muranko et al., 2018). However, studies often focus on customer behavior in the initial purchasing stage (Hazen et al., 2017), not the product's use phase.

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Single-use plastic gloves in the healthcare sector

Previous studies on single-use plastics have primarily focused on the potential for recycling (e.g., see Joseph et al., 2021; RISE Research Institutes of Sweden, 2019) and plastic waste management (Ramos et al., 2023). There are also studies on particular product types, such as formula bottles for infants (Leissner and Ryan-Fogarty, 2019), single-use medical sensors (Leppälä et al., 2023) and other medical devices (Guzzo et al., 2020; Lingegård et al., 2025). However, single-use nonsterile examination gloves, with a low end-of-life value, are unexplored. This type of glove (single-use, nonsterile examination glove) is by far the most commonly used single-use product in the healthcare system, and is used in various practices and situations across the healthcare sector.

In the past 10 years, the major trend for many items in the healthcare sector has been moving from multiple-use items to single-use items due to a combination of price reductions, convenience and the perception that they sustain and enhance hygiene (Bhutta, 2021). There are indications that the extensive use of single-use plastic gloves, in some situations, has replaced traditional washing and sanitizing practices (Lindberg et al., 2020; Haenen et al., 2022).

From a user perspective, some studies have examined the utilization of gloves by healthcare personnel, all focusing on clinical or healthcare viewpoints, focusing on the associated contamination risks. Research conducted in the Netherlands (Haenen et al., 2022) and Sweden (Lindberg et al., 2020) indicate a low adherence to the World Health Organization's hand sanitization requirements (WHO, 2009) in hospitals and care institutions, including reduced hand hygiene compliance caused by glove use in a UK case (Fuller et al., 2011) (Flores and Pevalin, 2006; Haenen et al., 2022). Furthermore, large-scale reduction interventions for glove use, such as the 2018 "The Gloves are Off" campaign in the United Kingdom (NHS, 2018);, underline a suggested widespread overuse of gloves (glove wearing with no hygiene indication) since the glove volumes decreased by 18% with no implication for healthcare-associated infections (Lalakea et al. 2025; Peters et al., 2025). Overall, the usage of gloves depends on several aspects related to individual risk perception, beliefs and experience, as well as organizational culture and social norms (Flores and Pevalin, 2006; Haenen et al., 2022). Several studies indicate overconfidence in correct glove usage; however, Kristiansen et al. (2024) found that observations did not confirm this, leading to the conclusion that determining optimal glove wearing causes problems in practice (Bate 2024).

Furthermore, using a double layer of gloves as an alternative to hand hygiene to save time contributes to excess consumption. Haenen et al. (2022) stressed the need for managers to facilitate hand hygiene practice and ensure adherence to hand hygiene guidelines (WHO, 2025). Additionally, one study examined the dispensing of gloves and how the design of dispensing boxes could reduce contamination of unused gloves (Assadian et al., 2016). Moreover, Singh et al. (2022) point to a lack of training in waste separation among medical staff, while Hu et al. (2022) identified the Covid-19 pandemic and associated rise in consumption of single-use plastic may be a catalyst for the development of more circular approaches in healthcare. Overall, Rizan et al. (2020, p. 51) conclude that while the excessive use of single-use plastic products is driven by infection concerns, "in many cases, the risk of infection is hypothetical or infinitesimal and poorly evidenced."

Method

This article applies a comparative approach to analyze the challenges and potential solutions for reducing single-use plastic examination gloves in the healthcare sector, using data from Sweden and Denmark. These two Nordic countries share close cultural and economic ties, and their healthcare systems are similarly structured: tax-financed, with hospitals typically managed at the regional level and elderly care organized by municipalities. These parallels simplify cross-border comparisons and enable discussions on circular solutions for glove consumption.

Healthcare practices in hospitals tend to be consistent across regions and countries due to several factors: (1) medical knowledge is globally shared and informs local guidelines, (2) sanitary protocols are often based on recommendations from international organizations like the WHO (2009) and (3) medical devices, such as gloves, are supplied by global companies offering standardized products. Additionally, at the operational level, healthcare workers often make decisions under time pressure, interpreting and implementing guidelines locally, which Nugus et al. (2018) described as "street-level bureaucracy." These dynamics underline the relevance of studying glove use in Sweden and Denmark, not only for understanding local practices but also for generating insights applicable to other countries and healthcare systems.

The context of the study

The Swedish data were obtained from the Region of Stockholm and the City of Stockholm. The two organizations deliver substantial publicly funded healthcare services every year, including hospitals and elderly care homes. The Danish data were obtained from three regions. The main responsibility of the regions in Denmark is the delivery of healthcare services, including the management of public hospitals.

Region Stockholm promotes sustainable consumption by integrating sustainability into procurement and aims to improve circular material flows through efficient resource use and collaboration (The Stockholm Region, 2019). The City of Stockholm similarly aims to become a resource-smart city by promoting resource efficiency, responsible consumption and material recirculation (The City of Stockholm, 2020).

In late 2023, the regions of Denmark published a common strategy for green hospitals, including three main tracks: (a) purchasing, (b) circular economy and behavior and (c) energy consumption, transport and buildings (Danske Regioner, 2023). The strategy also includes an overall climate objective.

Data collection

The study is based on workshops and interviews in Sweden and Denmark, complemented by public sector documents consisting of key policy documents and guidelines for plastic glove usage. Workshops were the main data source, while documents provided background on plastic-related policies, targets, strategies, purchasing volumes and guidelines on glove usage in hospitals. The documents were used in the analysis to understand the background for the behavior, practices and priorities of the workshop participants. The Danish documents included the national common strategy for green hospitals (Regioner, 2023), Danish regions procurement strategy (Danish Regions, 2020), national guidelines on glove use (Statens Serums Institut, 2021), guidelines on glove use provided by the regions (Central Region Denmark, 2021; Zealand, 2023) and glove procurement data provided by the Capital Region. The Swedish documents included the strategies and road maps for plastic use in healthcare (Swedish EPA, 2022; The Stockholm Region, 2019) and the national procurement strategy (Government Offices of Sweden, 2021), as well as national guidelines on glove use (The National Board

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of Health and Welfare, 2015b). The workshop format for data collection is appropriate when interviewing a group of people knowledgeable in the area, and where the interactive discussions lead to data not accessible through individual interviewing (Merriam and Tisdell, 2016). The initial analysis of the Swedish workshop indicated that the use phase is essential for resource reduction. Thus, the subsequent workshop in Denmark focused explicitly on this phase. A follow-up interview with a Swedish hygiene nurse provided data and additional details on glove use guidelines for Sweden, as this area was highlighted in the Danish workshop as critical. This interview (42 min) was done with a hygiene nurse from the Region of Stockholm on June 18, 2024. Participants were informed that the workshops were recorded, no direct quotes were used, and the study follows the European Code of Conduct for Research Integrity.

Workshop structure

The initial Swedish workshop was based on a framework (see Supplementary Table S1) derived from literature and interviews with some key participants. The workshop had a broader and more explorative scope than the second workshop since the aim was to focus on forward-reaching opportunities with the overarching aim of "Where do we want to go? What do we want to reach?." In this way, common obstacles to recycling techniques and regulatory aspects did not stop the discussion, as those questions were banked. The internal value chain, procurement, purchasing, use, and waste management set the organizational frame for the workshop. The EU waste hierarchy was well-known to the participants and thus served as a sound basis for discussion. Explaining the workshop's purpose and distributing the materials in advance allowed participants to prepare and feel confident.

Building on lessons learned from the Swedish workshop, the Danish workshop focused solely on the use phase and aimed to answer the question, "What factors influence glove usage in your organization?" In this way, complementary data for glove use in the healthcare context was collected, providing validation and complementary data. The Danish workshop was organized in three sessions focusing on (a) glove use praxis, (b) product and design and (c) frameworks and regulations. Participants were divided into three smaller groups, and sticky notes were used to identify contexts, problems and solutions in each of the three sessions and facilitate joint discussion.

Both workshops had too many participants for a full-group discussion, and the groups were split into subgroups with 6–10 participants to facilitate the discussion, as recommended by Patton (2002). Each of the two groups was accompanied by a researcher, who ensured the workshop format was maintained and took notes. Respondents with similar competencies were represented in both groups to reap synergies based on the complementary expertise of the participants. However, every effort was made to avoid silencing minority perspectives or lacking confidentiality (see Patton 2002). The participants covered various functions within the healthcare sector (see Table 1). The respondents were chosen to provide different perspectives on the glove usage in the public sector, both hospitals and elderly care homes. Only a few of them had sustainability as the main focus in their roles. The other representatives are hygiene nurses, controllers and so on, with different core focuses of their professions. This provides a nuanced picture of the topic, and different professional perspectives strengthen the study by providing a more comprehensive and practice-grounded understanding.

Data analysis

The procurement documents were compiled and analyzed to provide an overview of the volume of gloves used over the past years (see Figure 1).

Table 1. Healthcare systems and political objectives for healthcare services in Denmark and Sweden

	Sweden	Denmark
Administrative and political layers	3 – state, regions and municipalities	3 – state, regions and municipalities
Administrative layer responsible for hospitals/ elderly care homes	Regions/cities	Regions
Administrative layers covered in this paper	Stockholm region (2.5 million inhabitants) and the City of Stockholm (1 million inhabitants)	Capital region, Region Zealand and Central Region Denmark (total 3.9 million inhabitants)
Funding of healthcare services	Tax-based funding system that, within certain limits, provides free healthcare services	Tax-based funding system that, within certain limits, provides free healthcare services
Climate policy for the healthcare system	No separate climate objective for the healthcare system	Common Regional Strategy for Green Hospitals
Policy objective for the regional healthcare services City healthcare service	Net-zero emissions by 2045, with direct and indirect emissions cut in half per inhabitant by 2030 relative to 2014 Climate positive by 2030 and fossil-free by 2040	Common climate objective for Danish regions: 50% reduction in GHG emissions in 2035 relative to 2022
Procurement strategy, targeting plastic in healthcare	Roadmap for circular plastic flows within the Stockholm Region Action plan for sustainable plastic use in the city and reduced plastic use through procurement and a related carbon budget	Regional procurement strategy 2020–2025. We are purchasing for the patients – effective purchasing that helps patients and the climate
Main target in procurement strategy	To reduce total costs while maintaining high requirements for environmental and social sustainability, as well as robustness Procure according to the city's sustainable plastic action plan	Green purchasing should be the norm

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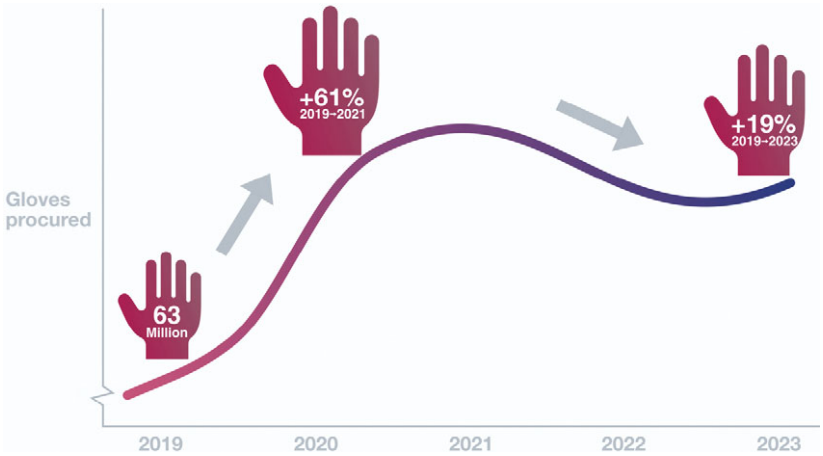


Figure 1. Volume of single-use examination gloves purchased by the Capital Region, Denmark, 2019–2023.

For the Swedish workshop material, the participating researchers compared notes and debriefed on critical elements of the discussions. The recordings were selectively transcribed (Flick, 2009), and the compiled notes were structured using the workshop framework. The Danish workshop was not recorded, but extensive notes were taken by the participating researchers and the workshop participants (using Post-its). The data analysis was conducted in several steps. The identified challenges were matched to the most relevant life cycle phases for their occurrence and proposed solutions through pattern matching (see Yin 2014). The data from the Swedish and Danish workshops are presented and categorized in Tables 2 and 3, respectively. An explanation and its consequences from an organizational perspective were stated for each challenge. The solutions proposed by the participants were linked to the respective 9R circular strategy with the best fit, which was ensured through clustering (Miles et al., 2013). Four categories of challenges emerged from this (see Tables 2 and 3): overuse, misuse, discarding and waste options. The data are discussed and compared between the two countries using these categories in relation to the R-strategies. Finally, the results are discussed within the broader context of single-use plastics to propose trajectories for reducing single-use plastics in healthcare.

Results and analysis

Status quo in procurement and regulations

This section reports and analyzes the study's results, starting with a cross-country analysis of the purchasing data for examination gloves. Second, challenges related to the use phase of gloves are presented and analyzed, and solutions are suggested.

Figure 1 shows the volumes of examination gloves purchased in the Danish Capital Region and used in hospitals. The data span from 2019 to 2023 and clearly shows an expected increase during the COVID-19 pandemic from already large volumes prior. From ca. 63 million gloves in 2019, a peak of 101 million was reached in 2021. Still, the purchasing levels in 2023 were 19% higher than pre-pandemic levels, at 75 million gloves. Data acquired from the Stockholm Region indicates a similar development, with pre-pandemic levels in 2019 reported to be ~100 million gloves.

Hygiene guidelines for glove use

In Sweden, the National Board for Health and Welfare outlines regulations on basic hygiene routines for all health and social care settings, specifying when and how to use personal protective equipment (The National Board for Health and Welfare, 2015a). In Denmark, glove use is guided by the National Infection Hygiene Guidelines (NIR), which require gloves in situations involving blood, body fluids or patient isolation and recommend hand hygiene before and after glove use (Statens Serum Institut, 2021). While Danish Regions implement NIR through tools like online learning, workshop participants questioned its effectiveness. The general nature of the guidelines enables local adaptation but also increases the risk of misinterpretation in practice. In Sweden, although similar online training exists, it is reportedly not in use in Region Stockholm. According to a hygiene nurse there, information and education about hygiene regulations are uncoordinated at both national and regional levels, limiting the effectiveness of these efforts.

Identified challenges and solutions for circular strategies of single-use gloves

In this section, the workshop data are presented and analyzed. Table 3 and 4 present the Swedish and Danish data results, providing insight into the similarities and differences between the two datasets. The results are analyzed based on the four categories in the analysis: overuse, misuse, discarding and waste options.

Overuse, misuse and the underlying reasons

Both workshops included discussions on *overuse* and *improper use/misuse*. Below, *overuse* is conceptualized as the extensive use of gloves when the purpose of using gloves, as defined by the guidelines (NIR in the Danish case), does not apply. *Misuse* is characterized as the incorrect use of gloves according to guidelines (NIR in the Danish case), for example, wearing a double set of gloves instead of a single pair or failing to use gloves when required. However, an important takeaway from the discussions in both workshops is that correct glove use depends on a professional interpretation of the guidelines in a specific situation.

Participants in both workshops identified widespread glove overuse, confirming trends seen in the quantitative data (Figure 1). Overuse was evident even before the COVID-19 pandemic, with usage increasing during the pandemic and not returning to pre-pandemic levels due to changed practices, shifting norms and a heightened focus on hygiene procedures. However, workshop

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Table 2. Respondents participating in the workshops

Country	Date, duration	Organization	Role
Sweden	November 10, 2023, 3 h	Stockholm Region	Hygiene nurse
			Hygiene nurse
			Environmental strategist
			Contract controller
			Environmental strategist, central
			Procurement/contract controller
			Category manager
		The City of Stockholm	Environmental specialist procurement, central organization
			Strategic procurer
			Environmental specialist, Environmental administration
			Nurse medical care responsible
			Project manager circularity, Environmental administration
Denmark	June 17, 2024, 4 h	The Capital Region Denmark	Project leader, Green Procurement
			Hygiene nurse
		Central Region Denmark	Project leader, Center for Sustainable Hospitals
			Hygiene nurse
			Hygiene nurse
			Circular economy advisor, Center for Sustainable Hospitals
		Region of Southern Denmark	Project leader, Green transition
		Region Zealand	Hygiene nurse
			Head nurse
			Climate action coordinator
			Climate action project leader
			Nurse
			Consultant, hospital management secretariat
			Chief consultant, climate secretariat

participants indicated that practices surrounding glove use are associated with multiple trends in the healthcare system and society at large. For example, younger staff tend to use gloves more frequently than their older colleagues, and gloves are often seen as part of the uniform rather than solely for hygiene purposes. Usage also varies by context; staff are less likely to wear gloves when treating children than when caring for elderly patients.

Most nurses will receive the basic hygiene routines within their education, but most of the time, they learn when they start practicing and thus adopt the praxis for that department. The results show that departmental praxis in the everyday procedures overrules the regulations, and the praxis differs depending on the department's culture. Culture, norms and routines shape glove use practices, and the relatively loose guidelines are interpreted to fit existing routines locally at department levels in the hospitals.

Discussions and reflections occur for departments requiring gloves, and plans are in place. However, respondents reported that no reflections are carried out for low-risk departments and that gloves are widely overused. In Denmark, guidelines for gloves are established at national, regional and local levels, leading to ambiguities and room for individual interpretation, which often results in overuse. However, according to the national guidelines, staff must carry out a risk assessment before using gloves, which can be challenging and lead to gloves being used *just in case*. Such practices can be further triggered by placing gloves in the rooms right by the doors and nudging staff toward excessive glove use. Local culture, practices and norms at the departments also influence glove usage, leading to overuse of gloves and use of gloves in situations that do not provide improved hygiene protection. The workshop data obtained from the participating hygiene nurses suggested that current practices might not result in high protection when correct hand sanitation is replaced with extensive glove usage. Similar insights have been found in Sweden, for example, gloves are used when there is a known infection, even though it is not transmitted through hand contact. This is among the many myths circulating about glove use in the healthcare sector. Group pressure is added to the list of reasons for overuse, as well as the taboo of correcting someone with more authority. A hygiene nurse explained that if the first person entering a room takes a pair of gloves, then the others will as well, and that the same is true for washing and sanitizing hands. Respondents suggested changing the location of the gloves to move further away from the door to encourage the washing and sanitizing of the hands instead. This should always be done before

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Table 3. Challenges identified for efficient and effective use of single-use gloves from a life cycle perspective, as well as proposed solutions in relation to circular strategies in the Swedish context

Challenge	Description	Cause	Challenge – life cycle phase	Circular strategy	Identified action/solution	Action/solution – life cycle phase
Overuse	Used when not needed	• 50% of total consumption is assumed to be overuse. ○ E.g., double gloves are worn due to an incorrect assumption of better infection risk mitigation	Use	Reduce	• Education on, e.g., more important to sanitize hands than to use gloves from a hygiene point of view	Use
	Used when not needed	• A belief that gloves protect, but there are holes in all gloves. False safety	Use	Refuse	• Change the culture of thinking that the staff is "cleaner" than the patient. A need to learn to protect the patient from the staff, not vice versa	Use
Discarding	Gloves fall out of the package when taking one pair out	• Nonfunctional packaging design. • Design of packages fits with a stand on the wall, one supplier only	Design	Reduce	• Design change of packages • Buy smaller packages to minimize the number of discarded gloves (fewer falls to the floor per package)	Design; procurement
	Contamination from hands	• People forget to sanitize their hands before touching the packaging. It takes too long to dry	Use	Reduce	• Appropriate distance between the sanitizer and the gloves for hands to dry. Only works in hospitals, not in elderly homes, due to the limitation of changes allowed in rooms	Use; design of facility
	Stockpile	• In the aftermath of the pandemic and the unreliable supply chains • Materials discarded due to expiration date passed	Use; End-of-life	Rethink	• Reducing glove routines through better education, use of scenarios, etc., can reduce the stockpiling pressure	Procurement
	Stockpile on units	• Every unit has its stock. Get contaminated or forgotten and then discarded	Use	Rethink	• Rethinking routines	Procurement; use
Limited waste management options	No recycling options	• Material cannot be recycled • More fractions require more space	End-of-life	Recycle	• Change to recyclable materials • Challenge the suppliers and design for recycling • Collaboration, use the same materials and standards	Design; procurement
	No reusable options	• No material or technology available	Design	Reuse	• Innovations • Pilot projects • Cost-effective process needed	Design
	No internal process for reusing gloves		End-of-life	Reuse	• Hydrogen peroxide for sanitization. Fast process but 4 h to dry. Could be used for gloves	End-of-life

glove use, but this is not the case for all users in both countries investigated. Sanitizing hands is more crucial than using gloves because the traditional single-use examination gloves are unsterilized. Staff mistakenly believe gloves offer more protection than they do, leading to a false sense of security.

Discarding

Hand sanitation is required to avoid contamination when dispensing gloves from a box. Nevertheless, respondents reported that not everyone follows this practice, leading to frequent contamination of the glove container. A Swedish hygiene nurse describes that when a patient is discharged, the room is cleaned and the glove container is discarded. This is more common in single-patient rooms than in rooms with multiple occupancy. A nurse carries out a risk assessment, but most of the time, the *just-in-case* approach is used, resulting in large volumes of discarded unused gloves. In the Swedish workshop, the discussion centered on reducing glove contamination by using smaller packets, even if this would result in higher purchasing costs. However, the follow-up interview with the hygiene nurse stated that a smaller glove container costs the same as a large one. Hence, in this situation, there appears to be no economic incentive to buy a smaller box to reduce the number of discarded gloves. Again, proper washing and sanitation of hands before touching the glove container would facilitate a lower contamination risk and, thus, alter the outcome of the risk assessment.

Additionally, respondents mention the box design and a suboptimal manufacturing process as contributors to discarded gloves. Multiple gloves can fall out when personnel tries to remove one, a problem mentioned in Swedish and Danish contexts. This is further related to the incorrect or sloppy layering of the gloves in the container, which causes them to become tangled.

A further aspect is the volume of discarded gloves due to extensive stockpiling, resulting in gloves passing their expiration date before use and needing to be discarded. This results from the convenience of having products close to patients (unit stockpiling) and the increased uncertainty in supply, which skyrocketed during the COVID-19 pandemic.

Limited waste management options

Challenges in waste management persist for used gloves, as they are designed for single use. Currently, there is no technology available to decontaminate and recycle the material. Besides the recycling process, waste sorting and logistics would be a challenge. Internal waste logistics and a lack of space for disposal boxes were also pointed out as hindering factors, as the gloves would require a separate material flow. In recent years, Swedish and Danish healthcare underwent a substantial efficiency push, for example, to optimize the limited space available and shorten the time healthcare professionals spend performing their tasks. According to the respondents, this has created new path dependency, as the organization of, for example, patient rooms is designed for the products and technology available when the change is made. Furthermore, even the short time spent deciding which recycling bin to use adds up on the typically highly intensive workdays, with respondents assuming that glove users will likely place all gloves into incineration just in case, rather than checking for contamination and selecting the recycling option.

The Swedish workshop explored the option of sanitizing gloves with hydrogen peroxide as a potential future method for reusing gloves. However, this would require an appropriate space and quality check for contamination. In Denmark, a pilot project has been conducted for reusable gloves (Re:GLOVE, 2024), focusing on designing and testing reusable and washable nitrile gloves. However, a commercial reusable examination glove is still not available.

Use phase challenge mitigation through circular strategies

The key insights from the results are the extensive overuse and misuse of gloves in the healthcare sector and the multiple identified solutions for reducing this extensive usage. The analysis of the workshop data suggests that cultural norms in departments and behavior practices often override existing guidelines, leading to excessive glove consumption. Healthcare professionals often overuse gloves, for example, by wearing double gloves due to concerns about durability or by using gloves when they are not needed, despite evidence that such practices are unnecessary (Kristiansen et al., 2024). This reflects broader findings showing that perceived infection risks are often hypothetical and lack strong empirical support (Rizan et al., 2020). Research also indicates that healthcare workers tend to prioritize personal safety over patient safety, reinforcing glove use at the expense of proper hand hygiene (Lindberg et al., 2020; Haenen et al., 2022). Addressing overuse requires education, managerial commitment and practical measures, such as limiting glove availability for nonessential tasks. Glove use should be more clearly integrated into hygiene guidelines and training, and WHO recommendations on glove accessibility should be critically assessed to avoid encouraging unnecessary use (WHO, 2009; Loveday et al., 2014). In the literature, the studies focusing on R1-Refuse (Kirchherr et al., 2017; Potting et al., 2017) typically relate to the design and manufacturing of a product, where the center of attention is on increasing production efficiency and reducing dependency on critical resources (Garcia-Saravia Ortiz-de-Montellano and van der Meer, 2022). In this study, however, the results suggest that the primary reduction potential lies in the product's use phase, specifically when healthcare staff decides whether to use gloves, providing new insight to the literature in the field. Table 5 summarizes the derived applications of the R strategies to single-use gloves in healthcare. The analysis reveals R2 (Reduce) as the most promising strategy, achievable via behavioral change, revised hygiene routines and demand planning. Strategies R3 (Reuse), R4 (Repair) and R5 (Refurbish) are largely infeasible due to contamination risks and the disposable nature of gloves in clinical settings. Long-term strategies, such as R6–R7 (Recover), face systemic barriers. R8 (Recycling) is limited by material heterogeneity, a lack of standardization and infrastructure deficits (Kurilova-Palisaitiene et al., 2018; Ivanović et al., 2022). Current disposal practices are driven by perceived contamination risks, leading to the unnecessary discarding of entire glove containers. Just-in-case usage, spatial constraints and default incineration practices (R9) are driven by perceived risk and efficiency demands, which are combined by limited staff training in waste sorting (Singh et al., 2022). Previous research on plastic waste in healthcare has largely focused on waste output rather than on opportunities for circularity within the supply chain (Ivanović et al., 2022). Overcoming the challenges requires engaging the entire supply chain (Alfina et al., 2025), from manufacturers to end-users, through the redesign of products and packaging, investment in sorting systems and public procurement mechanisms that reward circular (Witjes and Lozano, 2016; Alhola et al., 2019; Qazi and Appolloni, 2022). This aligns with calls for system-level change to enable sustainable healthcare practices.

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Table 4. Challenges identified for efficient and effective use of single-use gloves from a life cycle perspective, as well as proposed solutions in relation to circular strategies in the Danish context

Challenge	Description	Cause	Challenge – life cycle phase	Circular strategy	Identified action/solution	Action/solution – life cycle phase
Overuse	Guidelines are unclear Gloves are used when not needed (from a hygiene point of view)	• Room for individual interpretation of guidelines leads to overuse of gloves • Multiple guidelines (national, regional and local) cause	Use	Reduce	• Increased dialog in departments on proper glove use • Include right gloves use in e-learning modules • Inform about the right glove use when onboarding new staff • Increase focus on right glove use in educational programs	Use
	Guidelines are not followed	• Risk assessment is difficult, staff are using gloves when not strictly needed (using gloves *just in case*), causing overuse	Use	Reduce	• Clarify guidelines and make sure that staff follow guidelines • Include right glove use in e-learning modules • Inform about the right glove use when onboarding new staff	Use
	Culture and praxis	• Local (departments) practices that are not based on guidelines or data	Use	Reduce	• Management focuses on “right glove usage” • Create a common language about glove use	
	Accessibility	• Gloves are widely accessible, causing staff (and patients) to use gloves more than needed	Use	Reduce	• Nudging: Make gloves accessible in situations where gloves are meant to be used, and avoid	Use
	Precaution	• Because of unpredictability, staff will put on gloves before entering a care procedure without knowing if there is an actual need for them	Use	Reduce	• Nudge a workflow of sanitizing hands at the point of entry and assess whether the situation requires gloves	Use
	Use of double-layer gloves	• Two pairs of gloves are sometimes used to increase protection	Use	Reduce	• Clarify guidelines and make sure that staff follow guidelines • Include the right glove use in e-learning modules • Inform about the right glove use when onboarding new staff	
Discarding	Gloves fall out of the package when taking one pair out	• Nonfunctional packaging design	Design	Reduce	• Redesign packaging	Design and procurement
	Low-quality gloves	• Low-quality gloves were purchased during the Covid–19 pandemic, which would break when taken on	Use/waste	Reduce	• Purchase better quality gloves • Improve communication between the procurement department and users	Procurement
Limited waste management options	No recycling options	• No recyclable glove solutions are readily available • Requires a combination of a product, a washing solution and logistics	Design	Reduce	• Identify experiences from other hospitals • Test and demonstration	Design/product development/ implementation

Table 5. Application of 9R circular strategies to single-use gloves in healthcare

R-Strategy	Applicability	Key barriers	Recommended actions
R2 – Reduce	High	Norm-driven overuse, risk aversion and lack of behavioral incentives	Implement staff training, new hygiene routines and demand planning
R3 – Reuse	Very limited	Strict hygiene requirements, contamination risk	Not currently feasible in clinical settings
R4 – Repair	Inapplicable	Gloves are single-use and non-repairable	—
R5 – Refurbish/ Remanufacture/ Repurpose	Inapplicable	Product characteristics and infection risks	—
R6–R7 – Recover	Limited, long-term potential	Infrastructure gaps, recycling tech challenges and contamination concerns	Invest in recycling technologies, secure designated bins and logistics
R8 – Recycle	Long-term potential	Material heterogeneity, lack of standardization and sorting infrastructure	Encourage coordinated material specifications; integrate circular criteria into procurement and packaging design
R9 – Recovery	Widespread practice	Default incineration due to contamination protocols and logistical limits	Prioritize avoidance (R2); revise risk assessments; develop incentives to divert waste from incineration

Healthcare organizations that comprise highly skilled professionals at the front line are particularly complex when it comes to decision-making processes. Analyzing circular economy adoption in the public sector from the employees' perspective is essential because of their expertise within their organizations (Klein et al., 2022). While formal managers may be attributed with power, in practice, leadership is distributed, and informal leaders engage in leadership, making decisions that may counteract formal managers' decisions (Svensson and von Knorring, 2025). This situation is confirmed by the cases analyzed, where the staff have no economic incentives to change. Still, the potential to reduce glove consumption and minimize environmental impact is substantial. This suggests that the organization's environmental targets have minimal impact on operational decisions made in the healthcare sector. Previous research on circularity implementation suggests that an organization's prerequisites play a crucial role in implementing circular solutions, and contextual solutions are necessary to overcome organizational challenges (Lingegård and von Oelreich, 2023; Santos et al., 2025). Shifting away from a linear consumption model necessitates systemic changes that integrate circular principles into routine practices (Hofmann and Jaeger-Erben, 2020) and user behavior changes (de Sousa, 2023; Bączyk et al., 2024). This is especially important in the healthcare sector, where cultural norms often override guidelines, leading to excessive glove use (Rizan et al., 2020; Kristiansen et al., 2024). The results show that the users, the healthcare professionals, must support circular strategies for single-use plastics in the healthcare sector.

Conclusions and implications for plastic consumption

This study focuses on the use phase, in contrast to the mainstream literature on circular strategies for rethinking and reducing, which primarily focuses on the production phase and end-of-life phase. It highlights the impact of processes and behaviors in public organizations that cause large purchasing volumes of gloves. This is due to three main aspects: *the overuse of gloves, the misuse of gloves and the excessive discarding of gloves.*

These aspects relate directly to circular strategies. The Reduce strategy offers the greatest potential, achievable through behavioral and routine changes and increased awareness. Recycling holds long-term promise if supported by technological advances, while Recover, here incineration by default, remains the current standard practice. This highlights the immense potential for reducing single-use plastics in healthcare by focusing on the use phase. Furthermore, applying circular strategies at the most effective life cycle stage is crucial, as it refines how circular economy principles are implemented in practice.

The same arguments would be valid for other single-use plastics in healthcare with low end-of-life value, where the staff makes the final decision on use, for example, aprons and incontinence products. Behavioral change among healthcare staff will likely have a more profound impact than procurement policies, usage guidelines or environmental targets alone. Substantial changes are unlikely to occur unless financial and procedural incentives are aligned with sustainability goals, since institutional practices and path dependency remain major barriers. Bridging the gap between environmental goals and daily practices is essential for fostering a culture of circularity in healthcare. This understanding may be critical to both policy (guidelines regarding procurement and design) and practice (behavioral, incentive-focused and organizational adjustments), and this gap needs to be further explored.

The results of this study are of broad relevance to the general trend of consumption patterns in public healthcare institutions. Furthermore, single-use gloves represent an illustrative trajectory for increased single-use of many other items in the healthcare sector and the challenges that arise in their wake. A key limitation of the study is its geographical focus. While the findings align with initial UK studies, further research is needed in other regions and healthcare systems. Constraints in efficiency-driven Nordic systems may not apply elsewhere, and higher population density could ease the scaling of recycling.

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Data availability statement. The authors confirm that all data analyzed during this study are included in this published article. Summaries of the data collection are available upon request.

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