LOGO

Socio-environmental sustainability and Upcycling of health service waste towards sustainability: Reuse of Spundbond Meltblown Spundbond (SMS)

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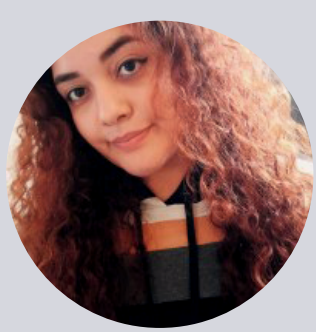

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ABSTRACT

This work aimed to define the steps for the Safe Capture of post-consumer Spundbond Meltblow Spundbond (SMS) non-woven fabric, and to estimate the generation of this material providing conditions for new uses through upcycling in a Surgical Center of a public hospital for means of application in socio-environmental projects. This is a descriptive, exploratory longitudinal study with a quantitative approach. As a result, a proposition was obtained for a new separation system for specific medical waste that is difficult to recycle, called Safe Capture in the Operating Room, as well as the implementation of SMS reuse in new products developed through upcycling, such as ecobags for make available to patients at the University Hospital of Londrina- HU. With the estimated generation of 140.89 grams per surgery or 18 SMS blankets of different sizes, the possibility of planning a storage infrastructure for this material for use in socio-environmental projects was envisaged through the development of products based on upcycling with focus on the circular economy, in this case reported and already implemented, the creative sewing workshop in partnership with the State Penitentiary of Londrina-PEL 02 where 3000 ecobags are made per month to store the belongings of patients, which caused a reduction of a portion of waste that would go to the infectious waste collector and, at the same time, replaced the use of plastic bags with ecobags, reducing costs. Currently, the possibility of using SMS has been expanded to other application niches such as interior design and the pet market, in partnership with the Veterinary Hospital of the State University of Londrina, which will revert part of the income from sales of pet products so that the Muda Project have a self-management for the purchase of new equipment and trimmings for the manufacture of products.

KEYWORDS

Hospital waste, Upcycling, Spundbond Meltblown Spundbond, Circular Economy, socioenvironmental sustainability

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1 INTRODUCTION

SMS packaging (Spunbond/Meltblown/Spunbond) is a type of product, in Brasil known for TNT, suitable for sterilization. It is composed of three layers in which the first and third perform the mechanical protection of the internal content and the second being the main responsible for microbial filtration. The specifications must meet those described in the NBR14990 Part 6 (SMS) standard. The TNT must present a minimum microbial barrier of 85%, in addition to tensile strength, elongation, tearing and air permeability as specified in the standard.

Spunbond Meltblown Spunbond (SMS) is a product known for TNT and formed by three thermally united blankets, formed exclusively by polypropylene fibers. The two external layers are called Spunbond, being formed by long and continuous fibers, in an orderly way, giving mechanical resistance and malleability to the material (ABINT, 2020). Among these layers is Meltblown, made up of a dense network of microfibers, being a filter element, with particle filtration efficiency >98%, bacteriological filtration >95% and with the ability to retain particles emitted by the user (Medeiros, 2020).

The textile industry focused on the health area has shown significant growth over the last few years, with the development of textile solutions, TNT for medical, dental, hospital and personal hygiene stands out. In the Material and Sterilization Center (CME) and Surgical Center (CC) it is very common to use this material as packaging or double casing to ensure aseptic technique, for reprocessing hospital medical materials.

According to the American Society for Testing Materials (ASTM) the term nonwoven does not include papers, flat fabrics, knits and fluffs; corresponds to a textile structure produced by the connection or interconnection of textile fibers through mechanical, chemical, thermal processes, through solvents and their possible combinations (American Society for Testing Materials, 1962).

To consider the possibility of a solution, it is important to know the composition and manufacturing process, this flat fabric “flat nonwoven” is manufactured involving two components, spunbond polypropylene and blown blown melt polypropylene. In the early 1970’s, the first facility was completed to produce micro denier webs leading to fabric fabrication from polymer using a single integrated process. The process today starts with thermoplastic chips being melted and then extruded. The extrusion is then constantly filtered and metered to produce the filament. The application of air during SMS manufacture causes its filaments to be

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stretched, making their diameters thinner, which will guarantee their thickness, in addition to improving the random placement of the filament.

Although the SMS can be produced offline by laminating layers of spunbond and meltblown webs, multi-denier spinning allows spunbonded and melt blown in a web that turns into TNT. This composite is then bonded together in a still fragile form and passed through rollers that use thermal bonding in its manufacture. Spunbond polypropylene has many great properties, strength and durability being just two of them. Still about it, Meltblown has relatively fragiles tensile properties, but due to the smaller fibers and the larger surface area absorbed by the fibers, it has excellent absorption and barrier properties. So together they can create a strong product that can also offer a fluid and particulate barrier, critical for hospital use (Site HG, Machimary, 2018).

The requirements of textile materials in the medical-hospital area demand that they have high filtration capacity, air permeability, lightweight and non-allergenic materials (Horrocks and Anand, 2000). Therefore, disposable clothing nonwovens using melt production technology are the most suitable for medical and hospital applications (Fung, 2000).

SMS-type TNT is a material made from 100% polypropylene, it is a type of packaging used in operating rooms that is difficult to recycle post-consumer, due to the need for high-cost technologies for its transformation, making the process difficult, even more so in medium and small cities. After consumption, it is discarded as infectious waste in health services, given the impossibility of recycling (Barbosa et al, 2020).

In turn, extending the useful life of this material represents an end-of-life strategy to be used to reduce the environmental, financial, production and consumption impacts of SMS in hospitals (Castro and Amatho, 2012).

In the operating rooms, during the process of assembling the room and the instrumentation table, with the opening of the countless materials packaged by SMS, it is noticed that in the post-consumer period, a large part of this material remains free of any contamination and completely safe for handling, which makes it possible to reuse this material for use in various socio-environmental projects through upcycling.

Upcycling is a sustainability strategy that consists of giving a new and better purpose to a material that would otherwise be discarded without degrading the quality and composition of the material. An item that has gone through upcycling may have a quality equal to or greater than that of it is original (SUNG et al;2014). Also known as creative reuse, it is the process of transforming by-products, waste, useless or unwanted

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products into new products.

In view of this, it was verified the need and feasibility of developing and systematizing a process of separation and safe capture so that it is possible to reuse this post-consumer material, contributing to sustainable practices in green operating rooms, such as the global recommendations proposals by the Global Agenda for Green and Healthy Hospitals - AGHVS (KARLINER; GUENTHER, 2013). This Agenda constitutes the main reference for the convergence of efforts in the search for solutions and the involvement of health professionals and from different areas in the search for strategies focused on environmental sustainability, as a strategy to meet the Sustainable Development Goals (SDGs) in the hospital sector.

In view of the above, strategies for the safe reuse of SMS-type TNT in operating rooms become more efficient and sustainable, but for the implementation of the separation of this material in a surgical center for upcycling, it is necessary to establish strict steps for the safe capture of the blankets, so that to ensure that they are not contaminated and also to estimate the amount generated with potential for reuse, based on the number of surgeries performed, which is the justification for this study.

There is a lack of knowledge in this regard, which may limit a more structured planning of segregation, packaging, transport and data to support partnerships in the medium and long term, which is the expected advancement of knowledge and contribution of this study, with the aim of define the steps for Safe Capture of post-consumer Spundbond Metblow Spundbond (SMS) non-woven fabric, and estimate the generation of this material to enable other uses through upcycling in a Surgical Center of a public hospital for application in socio-environmental projects.

2 METHDOLOGICAL PROCEDURES

This is a descriptive, exploratory longitudinal study with a quantitative approach. The study site was a tertiary hospital that has 502 beds distributed in different medical specialties, with exclusive care for the SUS. The surgical center has 07 operating rooms, where an average of 700 surgeries are performed per month, serving 17 medical specialties.

To define the safe capture process, a focus group was held with eight specialist nurses, where photos of the process of setting up the operating room and opening the packagesthe sterile packaging of the hospital under study were projected and discussion was stimulated. Upon reaching a consensus, it led to the understanding of the adopted safe capture

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process described in seven steps that must be performed before the start of the surgery. On the other hand, in the qualification phase of the nursing team, training was carried out for the nursing team that plays the role of circulating in the operating room and instrumentation. At the same time, 18 convicts from the prison system of the State Penitentiary of Londrina II, under conditions of deprivation of liberty, were trained to work in a creative sewing workshop, where they received training in cleaning and organization of the sector, straight and curved sewing, modeling and finishing.

The training took place in four theoretical-practical moments, with a total workload of 12 hours for nursing workers and convicts, covering all work shifts at the Surgical Center and work shift at the State Penitentiary of Londrina II. After six months of implementing the safe capture process, the stage of estimating the amount of separate SMS in the operating room and evaluating the SMS generation profile began, constituting the object of study the SMS blankets captured in the operating room. The stratified sample was calculated based on the historical series of the last years 2018, 2019 and 2020, and a sample of 354 stratified surgeries in all medical specialties was required. To reach the strata, 79 days of collection were required between the months of May and August 2020, totaling 848 surgeries, so that each specialty/stratum reached the expected number.

After the safe capture of this period, the SMS blankets were packed and soon after, separated by size, according to the sizes of the blankets: 1.20m x 1.20m, 1.00m x 1.00m, 0.75m x 0.75m , 0.60m x 0.60m, 0.50m x 0.50m and 0.40m x 0.40m and other non-standard sizes, and later quantified in units and transformed into numeric data in kilograms (Kg), as shown in the line of time, illustrated below (image 1):

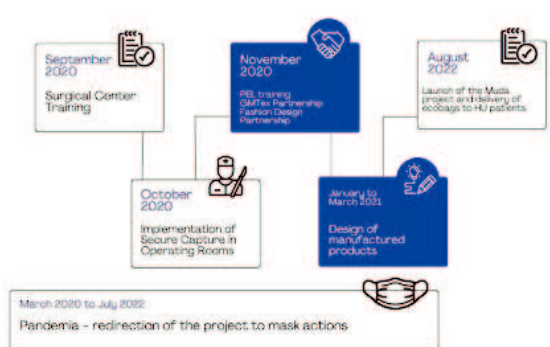

Image 1: Timeline of the study on secure capture and SMS upcycling. Source: Authors (2023).

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This study is linked to the research project: Sustainability and Cost Management in Health Services, in compliance with Resolutions 466/2012 and 510/2016 of the National Health Council and was approved by the Research Ethics Committee of UEL and the Extension Project Muda: reuse of surgical packaging for the manufacture of manufactured products with sustainability and rehabilitation for convicts in partnership with the research project Reverse logistics of industrial and post-consumer textile waste: design applied to sustainable systems and services and business models and Research Group Design , Sustainability and Innovation - DeSIn of the Department of Design at the State University of Londrina. Furthermore, this partnership between the Design and Nursing departments at UEL was supported by a jeans manufacturing company.

3 APPLICATIONS AND RESULTS

In the surgical center under study, it was a consensus among the consulted specialists to propose the separation of post-consumption SMS in the operating room only before the beginning of the surgery, in order to ensure that the others involved in the other stages did not have contact with SMS contaminated with material biological, to ensure safety and protection at all stages of the process of separating the material here called safe capture, with the following steps, as described below:

O centro cirúrgico em estudo, foi consenso entre os especialistas consultados a proposição da separação do SMS pós consumo em sala operatória somente antes do início do ato operatório, de modo a assegurar que os demais envolvidos nas outras etapas não tivessem contato com SMS contaminado com material biológico, para garantir segurança e proteção em todas as etapas do processo de separação do material aqui denominado de captura segura, contando com as seguintes etapas, conforme abaixo descritas:

1 -Hand washing;

2 -Opening the SMS package of surgical material with aseptic technique until the beginning of the surgical procedure;

3- Separation of the SMS blanket in a clean and dry place;

4- Visual inspection of the blankets and removal of adhesive tapes;

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5- SMS Plaid folding;

6- Storage of blankets in plastic boxes located outside the operating room, at the right time;

7- Daily transfer of plastic boxes for storage in exclusive stainless steel containers for this purpose.

Image 2: Steps for safe SMS capture in operating rooms. Source: Project Collection (2022).

This separation creates the possibility of safe reuse for everyone involved in the process, operating room, PEL and patient, highlighting the need to ensure that the SMS is free of any risk of biological contamination.

In the period of 79 days of data collection, seventeen medical specialties performed surgical procedures, as can be seen in the distribution in Table 1.

Surgical Clinic	Surgeries	Percentage (%)	Weight (grs)
Obstetrics	287	33,80%	4.269,3
Orthopedics	157	18,60%	3.349,4
Urology	88	10,40%	1.313,6
Neurosurgery	59	6,90%	871,5
Children's Surgery	58	6,80%	859
Surgical Emergency Room	52	6,10%	770,5

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Surgical Clinic	Surgeries	Percentage (%)	Weight (grs)
Vascular Surgery	30	3,50%	442
Ophthalmology	21	2,50%	315,8
Disgestive Tract Surgery	20	2,40%	303,1
Oral and Maxillofacial	17	2%	252,6
Gastroenterology	12	1,40%	177
Cardiology	12	1,40%	177
Thoracic Surgery	10	1,20%	151,5
Otorhinolaryngology	9	1,10%	139
Head and Neck Surgery	9	1,10%	139
Gynecology	5	0,60%	75,2
Plastic Surgery	2	0,20%	25,2
TOTAL	**848**	**100%**	**1.2631,2**

Table 1 – Distribution of surgeries performed by medical specialty in the months of May to August and Weight of SMS generated. Londrina-PR (2020). Source: Authors (2023).

The specialties that performed the most surgeries in the period were Obstetrics, Orthopedics and Urology, due to the Covid-19 pandemic period, which impacted on restrictions and permission only for emergency surgeries. The clinic with the highest number of surgeries (287) and SMS generation (4,269.3 Kg) was Obstetrics, followed by Urology with 157 surgeries generating 2,349.4 Kg and Orthopedics with (88) generating blankets of 1,313.6 Kg.

The stratification by size of SMS blankets already selected free of biological material, the individual and total weight can be seen in Table 2.

Size of SMS Blankets (cm)	Unit weight (grs)	Amount (Items)	Percentage by size	Total weight (grs)
40x40	9,6	1	0,1%	9,6
50x50	10,8	20	2,9%	216
60x60	13,3	33	4,7%	438,9
75x75	15,3	166	23,9%	2.539,8
100x100	19,3	267	38,3%	5.153,1

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Size of SMS Blankets (cm)	Unit weight (grs)	Amount (Items)	Percentage by size	Total weight (grs)
120x120	21,8	132	18,9%	2.877,6
Outros	17,9	78	11,2%	1.396,2
Total	**--**	**697**	**100%**	**12.631,20**

Table 2 - Distribution of unit weight, quantity and weight of HSE blanket by standard size. Londrina-PR (2020). Source: Authors (2023).

The average generation estimate per surgery is 140.89 grams, referring to each surgery generating an average of 18 blankets of varying sizes, depending on the surgical size and medical specialty. This size standardization derives from the availability of these materials for sales in surgical packaging used in the Material and Sterilization Center (CME).

The investigation of this work regarding SMS applications after its safe collection resulted in a study among nurses and designers about upcycling and the possibility of new products that could be developed from the reuse of the material. Initially, a reference research was carried out for products that could be used for such material in order to prospect market niches through desk research on different product sites.

The assumptions for selecting the products to be developed were that they were made from reused SMS, made by newly trained convicts in the creative workshop and with a low level of sewing complexity.

From the observation of the admission work routine of surgical patients to perform surgeries, it was found that their personal belongings, such as clothes, slippers, documents, exams, personal hygiene items and cell phones were packed in a simple plastic bag (bag of green garbage) and that, in addition to not being appropriate and humanized, could favor the diversion of belongings. Faced with this problem, we opted for products made specifically for this purpose, such as ecobags and SMS toiletry bags to properly pack the belongings of surgical patients.

Four models of bags were developed by fellows in the aforementioned research project, which involves a proposal for a reverse logistics system for textile waste, thus establishing a partnership between design and health professionals in a public hospital through Projeto Muda. After holding a vote with the employees of the Surgical Center to choose the best reusable Ecobag that would communicate an affective value for hospital patients as well as promote the resocialization of convicts by reducing the penalty with the work in sewing the bags, described in

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Martins et al (2022).

This proposal met the three dimensions of sustainability: social, environmental and economic, where the social bias is found in the insertion of the inmates of the State Penitentiary of Londrina-PEL 02 in work and sentence reduction as well as in the reception of surgical patients, who receive ecobags to properly pack their belongings during their hospital stay. The economic aspect is found in the reduction of hospital costs with the disposal of SMS as infectious waste and in the reduction in the purchase of plastic bags for patients' belongings, and the environmental pillar is met through the reuse of material that would be discarded in the creation of a product with greater added value, in the intrinsic awareness of the project and in the innovative study of upcycling of hospital materials captured in a safe way (figure 4).

Figure 4: SMS upcycling process captured in operating rooms. Source: Authors (2022).

Due to the appearance and characteristics of the material, the ideal application found was in linings and filling layers for products, since the material would be internal to the product coupling the filling, preferably of recycled origin. To gather and analyze the possibilities of applying the material in new products, a panel was created with the references found.

In this analysis, it was possible to identify the pet bed and pillows as the most viable products, since the SMS can be used as a filling cover, without the standard blue aesthetic of the hospital material compromising the result of the product. Furthermore, the possibility of a partnership between the University Hospital and the UEL Veterinary Hospital to commercialize the pet beds developed in the aforementioned research project is also highlighted. Cushions and pet beds were prototyped (image 3) in partnership with a jeans manufacturing company in the city

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of Londrina and the Textile Waste Bank system implemented in the same city, which systematized the collection of industrial and post-consumer textile waste, preventing such waste from be sent to the city landfill. Using the SMS as an inner layer, the textile waste that is shredded and processed, used as filling, comes from the Textile Waste Bank (B.R.T.), a pioneering system in the country with a pilot implemented in a cooperative of recyclable materials in Londrina, responsible for collecting, processing and disposing of correctly industrial and post-use textile waste from the city. The outer cover was made from industrial textile waste of jeans and cotton twill from a jeans manufacturing company and a partner of the B.R.T system. (MASSI et al 2020; 2022).

Image 3: Products prototyped with SMS. Source: Project collection (2022).

The implementation of the project took place in early 2022, when the University Hospital began to separate the SMS blankets to be forwarded to a jeans industry in the city of Londrina to be cut into layers. One of the difficulties encountered during the cutting stage was the standardization of the layers, as there is a wide variety of SMS sizes and this made it difficult to establish a base size for the layers and cut to use 100% of the fabric. In the case of ecobags, it was proposed to create 2 final sizes for this product in order to optimize the cutting process, which alleviated the problem and increased the performance of the blankets. As a result, a value-added product was obtained because it was a product built through upcycling (Figure 5) and with high emotional value, since patients would no longer put their belongings in plastic bags, but in bags made especially for them.

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Figure 5: Result of ecobags made from SMS upcycling and how they reach patients.
Source: Project collection (2022).

Next, figure 6 illustrates and summarizes the processes and flows of the previously described results:

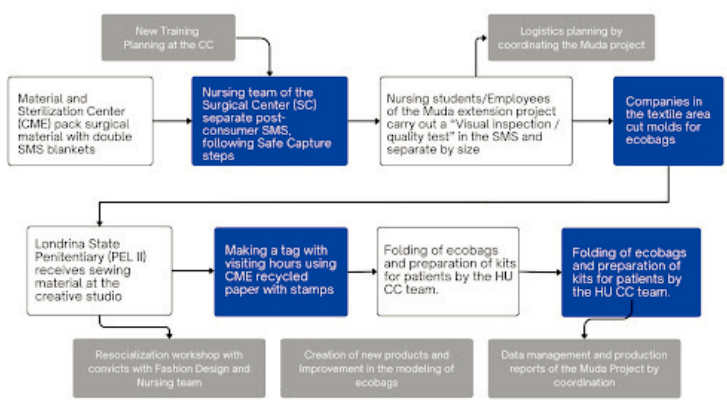

Figure 6: Muda Project Mapping. Source: Authors (2023).

4 DISCUSSION

Duque (2015) showed that the reuse of blankets brings positive results in four areas: environmental, economic, social and administrative, being interconnected. This action reduces the amount of hospital waste that would otherwise be discarded in the environment, contributing to a lower environmental impact.

Through the upcycling strategy, the material that would be discarded with generation of cost for the destination, can be used as a textile support for social projects, in the manufacture of manufactured products,

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either for use by the hospital's own patients or in products developed in partnership with local businesses. Furthermore, it is of interest to the hospital administration, which seeks solutions and improvements in the institution, as it addresses the generation of value in the sustainability chain, valuing environmental policies, which must be present in the strategic plan of all business segments (BARBOSA et al., 2020).

According to the idea of Gunther (2008), the segregation and management of hospital waste are specific, and require adequate treatment that makes it possible to minimize extra-hospital environmental impacts, avoiding contamination and risk situations with the uncontrolled disposal of waste in the soil.

The study by Nogueira (2016) showed that there is an average of 3.72 kg of waste per surgery, analyzing the collection of 1,120 surgeries in 82 days. The weight in kilograms, generated by each surgical specialty, in the period of 79 days in the present study, demonstrated that this amount of waste could be reduced with reuse strategies, resulting in less environmental impact caused by waste, and reducing costs related to proper disposal , since the material is discarded as group A-Infectant with an average of R$ 1.10 per kilogram of waste, 50.6% of which is infectious (including sharps), 28.5% is non-recyclable and 19.2% recyclable (Nogueira, 2020), the reuse of SMS-type blankets would be a viable choice to reduce costs with hospital waste (NOGUEIRA, 2020).

During the 79 days of collection, 12.631 kg of SMS that could be reused were obtained from 848 surgeries. This collection is carried out safely, without contact with any contamination, being a process that preserves both the material that will be reused and the people who will separate or handle it later. With the feasibility of reuse, it is possible to use the material segregated through upcycling strategies in favor of the environment, with a view to reducing the environmental impacts generated by the SMS that would be discarded.

In view of this, the segregation of the blankets provides a reduction in the volume of waste generated, considering that the material is free of contamination and at the same time contributes to the reduction of environmental impacts generated by its disposal and economic gain, both in reducing costs for the hospital with the disposal of the RSS accounted for and mentioned above, as well as the reuse of a noble material such as the SMS, thus representing a sustainable practice aligned with the circular economy.

5 CONCLUSION

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The SMS-type blanket capture process proposed in the present study provides security both for those who perform the separation and for those who can reuse it after capturing it in the operating room, following the seven steps proposed in this study. Knowing the clinics that generate the most SMS blankets can guide strategic educational actions with circulating patients. Having a generation estimate reference value of 140.89 grams per surgery or 18 blankets, enables the planning of storage infrastructure and the development of upcycling products with a focus on the circular economy. One should also consider the size of SMS blankets to optimize the use of this material based on the amount generated, as well as promote and build partnerships for socio-environmental projects that may derive from SMS blankets after consumption in operating rooms. This safely captured material provides a range of possibilities for reuse in sustainable projects, contributes to strengthening the Principles of green hospitals, enables the reduction of costs generated with the inappropriate disposal of waste from health services, integrating design for sustainability and the circular economy.

The reuse of SMS in new value chains generates, as a consequence, a broader look at the materials that can be reused through upcycling, especially hospital materials, since such material tends to be considered as waste due to its origin. The present work demonstrates that with the safe capture of hospital waste it is possible to expand the discussion of upcycling and sustainability in the environmental, social and economic dimensions, in the hospital sector, through interdisciplinarity and systemic discussions.

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