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The Healthcare Sustainable Supply Chain 4.0: The Circular Economy Transition Conceptual Framework with the Corporate Social Responsibility Mirror

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Abstract: Concern regarding the circular economy and Industry 4.0 is starting to increase in the emerging countries. This research study aims to analyze the healthcare sustainable supply chain 4.0 by proposing the circular economy transition conceptual framework with the corporate social responsibility mirror. The authors developed an observation guideline to collect empirical data from a private healthcare institution located in Rio de Janeiro, which has been promoting investment in new technologies within its operations. The research observation is between January and April 2017. The results show the glass structure can be a channel that provides the lightning resources, the solar energy with the photovoltaic panels, and the water management. The corporate social responsibility links the social role in healthcare institutions with sustainable practices and it improves smart technologies. The applicability of the internet of things and the internet of services adds value to sustainable practices. The circular economy transition conceptual framework integrates the result analyses. The research concludes that the union among the triple bottom line, Industry 4.0, and the corporate social responsibility allows the transition from the linear model to the circular model and can improve the sustainable healthcare supply chain 4.0.

Keywords: circular economy; industry 4.0; corporate social responsibility; healthcare; sustainable supply chain; transition conceptual framework

1. Introduction

The circular economy concept, discussed in many studies [1–3], allows the identification of the opportunities from the fourth industrial revolution and sustainable practices [4,5]. Industry 4.0 inserted disruptive technologies and it can be present in the circular economy. The Internet of Things (IoT) and the Internet of Services (IoS) are some of the examples of these disruptive technologies. The triple bottom line (environment, society, and economy) leads to the 3R concept of the recreate, the recycle, and the reuse [6]. The aim to transform the linear concept in a circular one is reinforced, allowing a wider sense of motion to the process by changing it into a cycle. Ranta et al. [7] affirm that sustainable practices are alternatives for the transition between the two economy concepts. This cycle enables the

possibility to have the reverse process, delivering a product that is transformed either to the supplier as to the consumer. Therefore, it means to affirm that this cycle absorbs and enables reverse logistics.

The Sustainable Development Goals (SDGs) are parts of the commitment that many countries must keep. In 2015 the United Nations (UN) [8] established the 17 SDGs: No Poverty; Zero Hunger; Good Health and Well-Being; Quality Education; Gender Equality; Clean Water and Sanitation; Affordable and Clean Energy; Decent Work and Economic Growth; Industry, Innovation, and Infrastructure; Reduced Inequalities; Sustainable Cities and Communities; Responsible Consumption and Production; Climate Action; Life Below Water; Life on Land; Peace, Justice, and Strong Institutions; and Partnership for the Goals. The SDGs are challenges that promote a positive impact on the countries and their populations.

In 2017 more than half of the world population lived in the urban areas and by 2050 this number should increase into two thirds. The urbanization is totally connected to social and economic developments [9]. The International Energy Agency [10] presents on the Energy Efficiency 2018 Analysis and Outlooks to 2040 that the use of the efficient energy impacts on the triple bottom line. According to UN standards, electric energy is delivered to 13% of the world population, considering it as a factor for climate changes. The UN affirms that this contribution represents around 60% of gas emissions and sharing of renewable energy in final energy consumed has reached 17. 5% in 2015.

The global movement brings the insertion of the circular economy and the fourth industrial revolution to the routine of the global population. The concern towards the world population increases also the perspectives for the implementation of the circular economy concept. This concept allows the reuse [11] the repair, and the recondition of the products. Some solutions offered by companies like the Product Service System (PSS) seek to meet customer satisfaction, the needs presented by the market, and the concerns about the environmental aspect of sustainability [12], as well as the social and economic aspects [13]. Among the contributions offered in Ardolino et al. [14] are the implementation and the role of the IoT, of the Cloud Computing (CC), and of the Predictive Analytics (PA). This implementation promotes the role of these technologies in the transformation of services.

The implementation of the circular economy in the fourth industrial revolution brings opportunities and challenges in the economic transformation scenario for many emerging countries like Brazil. Corporate Social Responsibility (CSR) can help and can accelerate this implementation, allowing the development of the companies. Some literature gaps are presented as the supply chain and its residues for biomass production [15]. These authors propose a methodology for the waste biomass projection.

The main objective of this research is to analyze the healthcare sustainable supply chain 4.0 and to propose the circular economy transition conceptual framework searching for the implementation of the healthcare sustainable supply chain. Therefore, the authors motivated by the concern that reaches the whole world establish the following three questions: Does the supply chain from the circular economy perspective attend the requirements of the sustainable supply chain? How does Industry 4.0 influence the circular supply chain? What are the expected results with CSR implementation in the sustainable supply chain?

The research study proposes a way for the adoption of the measures that allow the insertion of the transition conceptual framework for achieving the healthcare sustainable supply chain 4.0. The measures result in the alignment with CSR and enhance the image of the healthcare institutional brand. The ethical principles can be observed, since they must support initiatives in any social segments. Industry 4.0 and sustainable practices can be integrated and are capable of bringing contributions to the market through strengthening quality programs. These applications allow competitiveness through the offer of new products and better services. The natural resource management, as well as the natural resource use, will be covered in this research study, in addition to the disruptive technologies brought by Industry 4.0. Moreover, conceptualizing the term sustainability, its broad meaning in healthcare institutions is related to the environment, society, and the economy. The integration between the circular economy and Industry 4.0 for creating the sustainable supply chain searches to produce a model to disseminate these practices through CSR. This research reinforces the circular economy in Industry 4.0 applied in the healthcare supply chain with CSR use.

The research study is structured in a way to present the "Theoretical Background" after the Introduction, aiming to bring the recent publishing related to the items discussed. In the "Materials and Methods" Section, it is possible to see the data collection development and the study scenario characterization. The "Results" Section shows through its three subsections the models that compose the framework basis. These models are also presented in the "Discussion" Section together with "CSR improving the efficient natural resource use" and "sustainable practices and smart technologies." Finally, the Conclusions offer the contributions of the authors of this paper, as well as the limitations found throughout this research study.

2. Theoretical Background

The Theoretical Background Section is organized into four subsections: "Industry 4.0," "The Supply chain sustainability and Corporate social responsibility," "The Circular economy," and "The Healthcare supply chain 4.0."

2.1. Industry 4.0

Industry 4.0 is a concept that encompasses automation and information technology, besides some of the main technological innovations of these fields [16]. According to Luthra and Mangla [17], Industry 4.0 initiatives help industries to incorporate actions for the environmental protection and control, besides mitigating the risks of the supply chain, turning them into sustainable supply chains. A sustainable supply chain aims to project, to plan, and to operate supply chains that may guarantee the market needs, taking into consideration not only the profits, but also the environmental and social concerns [18]. For instance, the IoT use can bring benefits simultaneously in all dimensions of the triple bottom line [19].

The sustainable development and the circular economy are parallel issues that may affect the competitiveness of the companies. However, this systemic transition requires the development of the Information and Communication Technology (ICT), like the IoT [5], besides the participation and commitment of those involved in the process. Industry 4.0 provides a robust warehouse, information and communication systems, assisting management, potentially reducing costs, and increasing customer satisfaction [20]. According to Stock et al. [21], Industry 4.0 implementation results on the creation of the potential industrial value focused on sustainable development. Stock et al. [21] highlight a better integration and inclusion of these contributors, the increased value added to work, and a more targeted and qualified education of the employees, besides contributing for the harmony between professional and family life as benefits under the social dimension scope.

The sustainable supply chain, and simultaneously 4.0, can be defined as the supply chain that uses Industry 4.0 tools in order to close the material and energy cycles, besides helping the information flow and the activities, turning the operations more efficient, more intelligent, more precise, and quicker. Kovacs [22] reinforces the educational aspects for human resource development, creating skills, and the knowledge to deal with the digital economy. These educational aspects promote the fourth industrial revolution changes on the productions and on the organizations [23]. The positive impact of the digital technologies, provided by Industry 4.0, is perceived as the digital technologies lead to improve the supply chain performance.

2.2. The Supply Chain Sustainability and Corporate Social Responsibility

Due to the technological leap coming from the fourth industrial revolution, it is fundamental for the companies and their contributors to be prepared to deal with the changes imposed on their daily routines [24]. According to Gruchmann et al. [25], the consumer can be insensitive to sustainable practices because current communication is insufficient to diffuse them between them. Therefore, CSR can work as a bridge between the social responsibility goals of the institutions and the implementation of sustainable practices and smart technologies [26].

The healthcare institutions have already absorbed CSR favoring the democratizing of sustainable practices and establishing accessibility to other healthcare institutions. Democratization can be approached as the universalization of the opportunities [27]. The healthcare institutions can voluntarily have adopted CSR bringing a positive contribution to society. The regulatory, ethical, and social responsibility aspects support CSR use [26,28].

CSR use corroborates and strengthens the healthcare institutional brand in project development. The ethical principles are part of the institution's philosophy and are currently a reason for great pride and enormous differential. Many institutions have already established these practices, but it needs for broadening and showcasing them [29]. The social responsibility of healthcare institutions is also supported by its commitment to the sustainable global goals. These global goals enable to influence the common good of the world population. Sustainable practices, when inserted into CSR use, favor the link with the social responsibilities of healthcare institutions, which choose this path of working.

2.3. The Circular Economy

With the population growth and urbanization, many sectors of the global market are attentive to a number of challenges, including food security, energy scarcity, and water safety [30]. Many parts of society that may have its attention focused on sustainable strategies. These applications add value to the economy and bring some thought over the ethics concepts, the awareness, and the transformation of the social environment. The transition from the linear to the circular concepts provides opportunities to manage waste production [5].

The world discussions around climate changes and the need to speed the implementation of sustainable practices have stimulated the authors of the present research. Maalouf and El-Fadel [31] propose a framework involving gas emissions (CO2, CH4, and N2O), residue management, and emission ways (direct and indirect). They also observe that the landfill takes the first position regarding gas emission and reinforce recycling as an essential practice for the reduction of this emission. Chen and Xiang [32] approach carbon dioxide emissions by evaluation of the cost reduction. Gallagher et al. [33] and Balaman et al. [15] present the concern about climate change and greenhouses gas emissions.

Jabbour et al. [34] found out that decision making regarding the management of sustainable operations implies a connection between the circular economy approach and Industry 4.0 principles. It based on the conceptual approach of sustainable operations management and to implement organizational strategies based on the circular economy principles.

2.4. The Healthcare Supply Chain 4.0

The management of the sustainable healthcare supply chain involves information, supply, suppliers, service providers, internal and external customers, and end users [35]. Economic sustainability can be perceived by the objective of the cost control, moving and offering goods and services in a timeline that starts with the supplier and ends with the end user, integrating the processes [36]. The experiences of the industrial area are welcomed by the healthcare supply chain and, in addition, disruptive technologies, like those already mentioned, facilitate the work of healthcare institutions. As a result, healthcare institutions, by bringing the disruptive technologies together in their supply chains, opens avenues to be paved with the fourth industrial revolution, to be called the healthcare supply chain 4.0. The healthcare supply chain 4.0 brings together, in addition to Industry 4.0 technologies, sustainable practices. This union presented by Stock [21] brings the SDGs to the fore, allowing contributions to the implementation of UN Agenda 2030.

3. Materials and Methods

The research is exploratory, consistent with the emerging field of the topic [37,38]. An empirical study was conducted, consisting of "knowledge based on real world observations or experiment" used "to describe field-based research which uses data gathered from naturally occurring situations or experiments" [39] (p. 251). It served as a primary source of the information through filed visits

for direct observation. There was no direct intervention or participation from the researchers with the object of study, as would happen with action research [40,41]. The research observation period was developed from January to April 2017 in the private healthcare institution. The observational guideline used is provided in Figure 1 and was guided by the research questions provided in the introduction of this paper and on the theoretical background (with part of it adapted from Thomé et al. [42]). The healthcare institution is located in the Rio de Janeiro City and counts with around 250 beds and 11 operation rooms (from which one is hybrid). The hybrid room aims to attend the surgical teams on its procedures that may need the use of the image simultaneously to surgical features. The sample selection was conducted base on its conceptual representativeness, as opposed to sampling selection for large populations [42]. The healthcare institution in which the study was developed promotes investment on the implementation of the new technologies, like the traceability of healthcare products and the electronic registration of the information about the patients, for example, in order to bring agility and safety to the processes. The research analyzes the healthcare sustainable supply chain 4.0 through the circular economy transition conceptual framework with the corporate social responsibility mirror. The focus is the private healthcare institution building located in countries called "developing countries." The authors of this research study understand, through the observation during working activities in healthcare institutions, that many opportunities are presented. These opportunities involve: The creation and the implementation of the green structure in the healthcare building and healthcare institutions can contribute to reaching the UN goals.

The observation period made it possible to rethink the hospital structure and to analyze the insertion of the new elements into the physical structure and the work environment. The insertion of the circular economy and the disruptive technologies of the fourth industrial revolution was the object of this look during the observation period. Based on this observation, three models were selected: The first model concerns the use of the natural light with the use of the glasses controlled by disruptive technology; the second model is also related to the reduction of electric energy consumption, but taking a look at the use of this energy also during the night; and the third model emphasizes the water and the waste management. Industry 4.0 tools can control these managements.

For each proposed model, four supply chain dimensions are presented: "The time dimension," "the infrastructure dimension," the cost dimension," and "the institutional dimension." These dimensions were structured to draw attention to the research questions. At "the time dimension" the concern is about: The time impact, the acceleration or the expansion, the products processing, the well-being of the supply chain professionals, and the economic benefits for healthcare institutions. "The infrastructure dimension" considers the physical structure influence in the healthcare supply chain and its impact for each proposed model. "The cost dimension" is reflected in all the other dimensions. This dimension searches to promote a cost reduction with a positive impact, considering the maintenance and process quality improvement. Finally, "the institutional dimension" involves the healthcare institution role and is considered the legal aspects for the implementation. CSR and SDG contributions are applicable for all the dimensions presented in the observation guideline.

CSR can be a guidance for the implementation of sustainable practices [43]. This green structure contributes the UN goals, mainly with: The affordable and clean energy; the climate action; the decent work and economic growth; the good health and well-being; and also with: Industry, innovation, and infrastructure; partnerships for the goals; and sustainable cities and communities. This green structure reinforces that the SDGs are not isolated, but are integrated between themselves. This integration, which establishes a connection with the SDGs, is healthy and independent in many cases. Through a holistic and positive approach, this connection may be highlighted that this interaction creates an increasing movement and it raises the level of many goals at the same time. It allows to accelerate the process for 2030 and to reach the aims established by the UN.

Models		Supply Chain			
		The Time Dimension	**The Infrastructure Dimension**	**The Cost Dimension**	**The Institutional Dimension**
FIRST	**The use of the natural light with the use of the glasses controlled by the disruptive technologies.** **The SDG attention:** Affordable and clean energy, Climate action, Decent work and economic growth, and Good health and well-being.	- Does the natural light influence the efficiency of the services? - Can the natural light reduce the waste coming from the artificial light? - Is it possible to provide better working conditions for the employees using the natural light? - Is it possible to implement the CSR using the natural light? - Can the healthcare institutions contribute for reaching the SDGs?	- Are there any barriers for working with the natural light? - Can the natural light improve the productive chain? - How does the current structure work?	- Is it possible to reduce costs using the natural light?	- Are there any evidences for the use of the natural light? - Can these actions serve as a model for other institutions?
SECOND	**The reduction of the electric energy consumption.** **The SDG attention:** Affordable and clean energy, Climate action, Decent work and economic growth, and Good health and well-being.	- Is the energy consumption reducible? - Does reducing the energy consumption bring benefits to the process? - Can the waste coming from the artificial light be reduced? - Is it possible to implement the CSR by reducing the electric energy consumption? - Can the healthcare institutions contribute for reaching the SDGs?	- How can the disruptive technologies contribute for reducing the energy consumption?	- How to reduce costs using the technologies for the use of the natural light? - Can the costs be reduced using the natural energy? - Can savings generated by the cost reduction be reversed in improvements of the working conditions?	- Are there any evidences to search for reducing the energy consumption? - Can these actions serve as a model for other institutions?
THIRD	**The water and waste management** **The SDG attention:** Affordable and clean energy, Climate action, Decent work and economic growth, and Good health and well-being.	- How can the water be reused? - Can the CSR comprehend the water reuse and the waste reduction? - Can the healthcare institutions contribute for reaching the SDGs?	- How can the disruptive technologies contribute for the water reuse and the waste reduction?	- Can the water reuse minimize costs?	- Are there any evidences for employing of reused water? - Can these actions serve as a model for other institutions?

Figure 1. The observation guideline.

The literature review about the circular economy and Industry 4.0 was without any time restrictions. The purpose of this literature review can help the authors to establish the correlation between the circular economy and Industry 4.0 concepts. The selection of these journal papers has also the following inclusion criteria: Journal papers in English, with Digital Objective Identifier (DOI), and with a peer-reviewed journal. The choice of only considering peer-reviewed journals is consistent with many authors of the literature as a strategy to maximize quality papers in the sample (e.g., [44,45]). The selection searched the terms: "Circular economy AND Industry 4.0," "circular economy AND digital," "circular economy AND smart," "circular economy AND technology," "circular economy AND technologies" in the title. The search included more than two different databases, following the suggestion offered in Thomé et al. [46] for literature reviews. Therefore, following Science Publishers where chosen: Cross Mark, Elsevier, Emerald Insight, MDPI, Springer, Taylor and Francis Group, and Willey Online.

4. Results

The world concern regarding climate changes enables innovating thoughts for the insertion of smart and sustainable technologies in healthcare institutions. These insertions may be aligned to the physical structure and the healthcare supply chain. On the present research study, the authors have chosen the use of glass as wall structure, the inclusion of the photovoltaic panels, and the water and waste management. Industry 4.0 applications controlled the insertions mentioned, allow stimulating the efficient use of energy, the temperature, the lighting, and the reduction of the residues production. Sun et al. [47] refer to modeling with the approach of the ecological benefits, the circular economy practices, and the industrial applications. The research provides the development of the eco-industry in China.

4.1. Lighting Resources: Glass Structures and Solar Energy

The healthcare institutions can have high energy consumption and the possibility of adopting the use of solar energy is a path. This high energy consumption can be justified by the use of artificial lighting and of the equipment during the day and the night. The intensive care, surgical center, and central sterilization sterile supply units are examples of the high energy consumption, due to the amount and kind of equipment used. This kind of consumption is highlighted and its energy is directed to the ambiance lighting.

The efficient use of solar energy for the ambiance lighting can be one of the resources used in order to reduce energy waste. This is one of the concerns of the UN and the subject of the studies [48,49]. The glass offers a number of the options for the construction business, the possibility of the efficient use of daylight, as well as visual comfort. It can be used in walls, providing natural lighting during the day and saving energy of healthcare institutions. Besides natural lighting, glass provides comfort for the professionals whose responsibility is to deal with complex supply chain and repetitive actions, especially in institutions located in green areas, and those which visual is comforting for the healthcare professionals.

Pao and Chen [50] refer to an interdependence character among the environmental, energy, and the economy for global growth, strengthening the environment protection. Therefore, it would bring energy conservation policies, the sustainable use of energy, and the dissociation of the environmental pressure from economic growth.

The glass walls bring thermal balance in the urban areas, where the temperatures are normally high. Another possibility would be glass walls and green roofs in order to reduce the temperature inside healthcare institutions. In cities where the violence rates are high, it might be considered to use armored glass. It allows the healthcare professional staff and the safety of the patients in extreme situations. For the healthcare buildings vertical and horizontal structures, it is also an option regarding privacy, in addition to every aspect previously mentioned. This evaluation is also appropriate for the case of the healthcare institutions that have many buildings around them. Pombo et al. [51] assess

the environmental perspective and its impacts on their study. Among these impacts, the demand energy reduction, the increase of the building material, and the potential increase of global warming can be listed.

4.2. Energy Resources: Photovoltaic Panels and Solar Energy

The concern towards energy obtaining through renewable sources and the natural means enables a discussion around the physical structure of the healthcare units. A holistic view from the administrators, the engineers, and the architects is a good opportunity to rethink energy obtaining. The search to implement the use of the photovoltaic panels guarantees that solar energy is captured during the day, collecting enough energy to support the night shift and with low sun exposure [52,53]. The energy storage would supply the lighting and cooling systems (Figure 2).

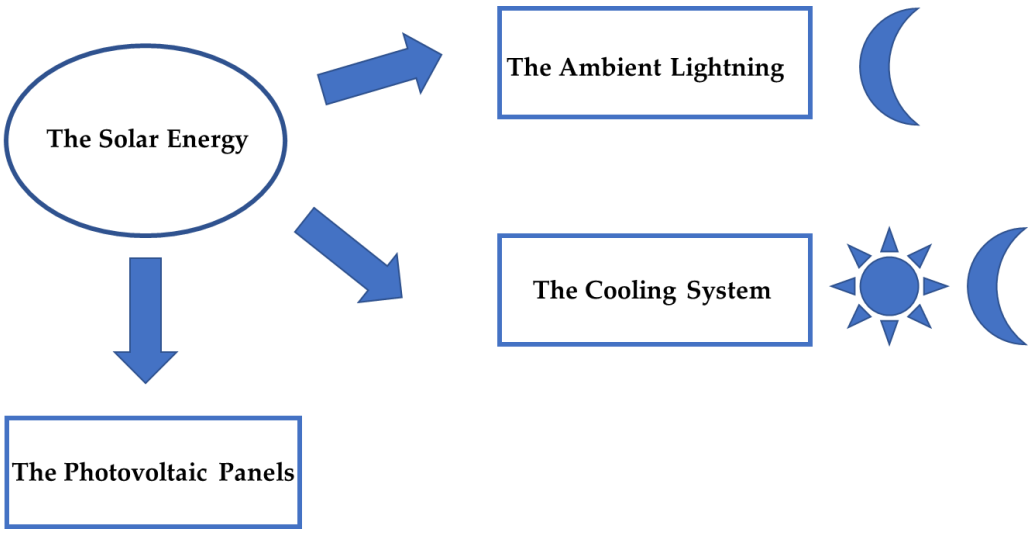

Figure 2. The structure to implement the photovoltaic panels.

The Urban Agenda for the European Union [54] establishes an energy transition on its priority list. This priority list aims the long-term change from the current energy supply to renewable energy through efficient energy. The study made by Chen and Xiang [32] highlights that China is responsible for a huge amount of energy use and carbon dioxide emission. This level of consumption is one of the concerns of the Chinese government that provides a stimulus for the reduction of the current rates and the use of efficient energy.

Brazil, an emerging country, still moves shyly through the insertion of this kind of energy in healthcare institutions. Martins et al. [55] point on their study that Brazil has plenty of the potential to apply photovoltaic energy systems. This kind of energy is one of the most viable and renewable technologies available. They reinforce that Brazil is a potential country to apply this energy use because of the solar resources available and worship the applicability of it in the urban area. For Chile, the promotion of renewable energy aims to reach a 20% rate of production by 2025. Among renewable energy sources are the photovoltaic, the concentrated solar power, and the industrial heat supply plants [56].

The research led by Zhang et al. [57] presents growth taxes on many kinds of renewable energy from 2013 to 2016. In order of the growth taxes, it is possible to mention: Hydropower, wind power, solar photovoltaic, biomass energy, geothermal energy, and solar thermal power. The study made by Wang and Lin [58] shows the concern with energy consumption and the points out that its use per capita in China is relatively low, in comparison to other countries. Tziogas et al. [59] make a critical analysis and reveal that sustainability and energy security are two broadly expanding research areas.

Rafique et al. [60] affirm that the electrification and the unit rate of the electricity are important points for social and economic development.

The foreign direct investment in China brings the progress of the technologies and the impacts on the efficient use of electric energy. This is one of the topics presented in the study developed by Xin-gang et al. [61]. The same authors analyze the impact of the foreign production by the direct investment on the host country production factors, like: The capital, the labor, the management experience and the innovation, the knowledge, and the technology.

4.3. Water Resources: Waste Management

The water is a natural resource that enables the generation of electric energy, the urban supply for daily use, and is also a base element that makes the hard technologies use possible. In healthcare institutions, it is possible to see it in these three moments, in which the last one can be exemplified by the water used in the electric stream generators and the boilers.

The water has its official day on March 22nd. This concern is presented by 2017 World Water Development Report, through the United Nations, Educational, Scientific, and Cultural Organizational Director-General Irina Bokova report [62]. The Director-General reinforces the management of the water residues treatment in order to reduce pollution, to remove contaminant agents, allowing its reuse, as well as to improve the social acceptance for the use of the treated water as a strategic move towards the future. The water pollution is widely discussed by researchers [63,64], who search for evidence for the contaminant's removal.

In healthcare institutions, factors like the size, the equipment, and the specializations attended might be different, and it influences directly the water consumption. The management of the water residues might involve rainwater [65,66] for toilets reuse, likewise the possibility of choosing equipment with low water consumption for example. The reuse must be in accordance with the technical regulations like the Brazilian Standard National Association 15527 [67]. Other strategies, like internal campaigns for the correct use of common taps and its replacement by those activated by sensors are also worthy. In the central sterilization sterile supply unit, the processing of products management may provide huge water saving with the safe optimization of the sterilizing cycles. Therefore, the implementation of the new studies and the new technologies that might enhance the treatment of reused water brings the possibility to reach the proposal of the UN 2030 Agenda, with the full participation of healthcare institutions.

Another relevant aspect to be considered, besides the conscious use of energy, is the proper use of the water. A matter of full attention should be supported by the triple bottom line with the implementation of simple measures. In 2018, the Itaipu Hydroelectric, a Binational power plant (Brazil and Paraguay) [68], has received the United Nations members for the workshop. The theme was the 17 goals for sustainable development and among the 17 goals, the aims "the clean water and sanitization" and "the affordable and clean energy" were highlighted. Tseng et al. [4] reinforce the academic popularity of the term green supply chain since the beginning of the 20th century. The authors show the top fifteen countries by publications (China, United States, United Kingdom, India, Taiwan, Iran, Canada, Brazil, Italy, Malaysia, Denmark, France, Germany, Netherlands, and Hong Kong).

The traditional model of healthcare institutions has been establishing buildings that use a lot of brickwork and a few uses of sunlight. Natural resources are underestimated and some units are located underground healthcare institutions. A transitional framework proposes the exchange of the traditional model by the rational use of natural resources through the implementation of the circular economy in Industry 4.0. The use of a green area outside joining the landscaping techniques help the sustainable structure of the building and blend with the inside area. The presence of the photovoltaic panels structured for energy storage in amounts enough to supply the lighting systems during the night and the cooling day and night systems allow a relevant impact both on economic and environmental

aspects. The water management can be improving in healthcare institutions. The holistic view and the educational programs when implemented can help this management (Figure 3).

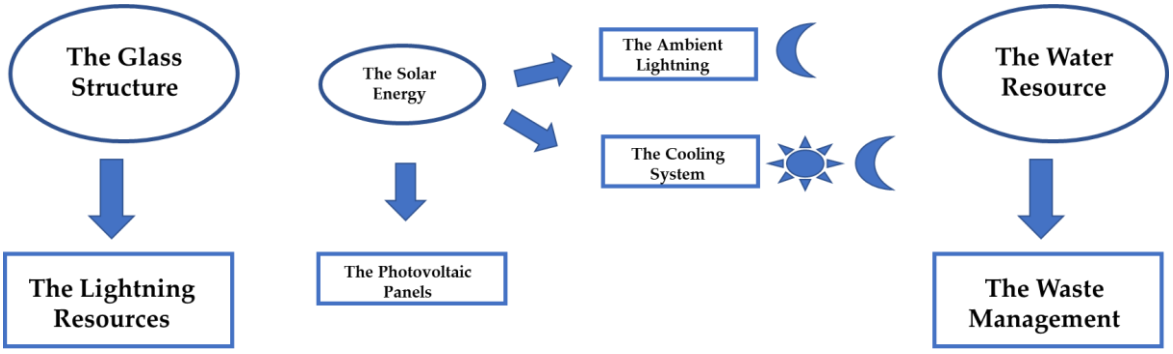

Figure 3. The integration among the glass, the photovoltaic panel, and water management.

5. Discussion

This section presents two subsections: "CSR improving the efficient natural resource use" and "sustainable practices and smart technologies." CSR insertion related to the efficient use of natural resources allows the establishment of a connection between the results and the questions that guided the present research study.

5.1. CSR Improving the Efficient Natural Resource Use

The healthcare institutions should exceed its role regarding primary, secondary, and tertiary attention towards the population health as a whole. This activity exceeds the common assistance principle and should embrace the global challenges and opportunities in a holistic view. By analyzing these topics through a macro vision, they can be brought to the reality of the healthcare institution itself, by means of the action and sharing experiences that enable the expansion of these actions, its success and attempts.

Bringing the social dimension of this responsibility inside healthcare institutions along the environmental and economic expectations creates a healthy wave made by a chain of the actions. The ethical aspects that surround this theme allow for a conscious awareness in order to realize how to contribute, to participate, and to strength movements in accordance with global sustainability.

In order to organize the development of "CSR improving the efficient natural resource use" subsection, the authors of this research study have divided it into three subsections: "Glass resources," "photovoltaic panels," and "water management."

5.1.1. Glass Resources

The utilization of glass as a mean to use natural resources, in addition to the comfort of the people and the professional setting should also be considered. Another aspect of the outdoors landscaping is the possibility to have pauses in a pleasant site while at work. The integration of the physical building and the green areas allows a more kind temperature. The Association for the Advancement of Medical Instrumentation ST79 [69] affirms that the healthcare products processing unit should follow the Engineering Society of North America (IES) guidelines. This association establishes specific categories for each activity developed on its units, including age range. CSR might influence the decision making of healthcare institutions, starting with the architectural project itself. The next subsection, "the photovoltaic panels", explains the photovoltaic panels and it establishes the same approach for the efficient natural resource use.

5.1.2. Photovoltaic Panels

The photovoltaic panel is a possible alternative to this study, but there might be other conscious uses of natural resources, like wind power. Many cities have the potential to apply this technology to energy storage. By using natural resources, the emission of carbon dioxide might be reduced. This structure needs to be rethought and structured by healthcare institutions that are under construction and by those that are being reformed and restructured. The purpose of the corporative awareness should not be established inside the healthcare institution, but should exceed the corporative boundaries and create a stimulus chain towards other institutions.

An approach on analysis and reduction of the cumulative energy demand of the product service system is made on Glatt et al. [70] study identify the relevant changes on product service system for the cumulative energy demand. These changes were assembled in technical (an increase of machine performance and efficiency increase by retrofit) and organizational (request provocative maintenance and training for employee). With the use of natural energy, emissions of the greenhouse gases are also reduced, thus, promoting possibilities to create a healthier environment and reduce poverty [71]. In addition to the photovoltaic panels, the authors of this research study also have the concern about the water management.

5.1.3. Water Management

The other application use of sustainable resources are the educational programs for the conscious use of the water, by establishing intern protocols for hand washing, the setting of the sensors in toilet taps and on hand washing station of the surgical centers. The establishment of a careful look towards the possibilities of the water reuse allows opportunities of sustainable conscience and CSR. CSR promotes responsibilities for the triple bottom line and ethical aspects. The promotion of the responsibilities enables the healthcare institution to solidify its brand and its image, as well as to the professional that works in the institution, to promote sustainable practices in personal life.

The third resource is shown in this study, water management, allows the reuse of the pluvial waters, but also the development of an educational program to control the use of these resources. The programs bring the healthcare staff and the institution a great help. The involvement enables conscious awareness and the replication of the practices in the domestic environment and it exceeds to the community.

At the end of this subsection, the authors propose the following hypotheses. These are a suggestion for future researches and a contribution to reinforcing new strategies for achieves the healthcare sustainable supply chain 4.0:

Hypotheses A:

Hypothesis A1. *Faced with the opportunities and the challenges associated with implementing the circular economy guidelines of Industry 4.0, CSR can contribute by integrating people and the environment with the SDGs of the institutions.*

Hypothesis A2. *CSR can contribute to healthcare institutions with implementing the social and ethical aspects in order to bring the ergonomic ambiance for the employees.*

Hypothesis A3. *The healthcare institutions role can allow other healthcare institutions to implement sustainable practices based on sharing experiences.*

Hypothesis A4. *Sustainable practices can modify the actual healthcare institutional physical structure.*

Hypothesis A5. *The healthcare institutions can improve their budgets with sustainable practice implementation.*

5.2. Sustainable Practices and Smart Technologies

On the fourth industrial revolution era, the IoT enables the integration and the use of some technologies, like glasses with sensors. The decrease on energy consumerism, the visual and thermic comfort for healthcare staff, patients, and their families, allows the use and the storage of natural resources and to inform and copy these actions in the social context. Opoku [72] concludes that biodiversity is enhanced through sustainable practice applications. The promotion of biodiversity can create possibilities to reinforce some points: The planet adaptation to climate change, the improving of the air quality, and the well-being of the population.

In order to organize the development of "sustainable practices and smart technologies" subsection, the authors of this research study have divided it into three subsections: "Glass resources and smart technologies," "photovoltaic and smart technologies," and "water management and smart technologies."

5.2.1. Glass Resources and Smart Technologies

The integration between the IoT and the IoS creates value through the disruption, providing a new paradigm, and supports the conceptual change of the production chain, that is, through the insertion of the digital technologies in the supply chain [73]. This conceptual change can be extrapolated, reflected, and adapted to the healthcare supply chain, especially in those areas where the production of healthcare products is adopted at healthcare institutions.

Through this integration between IoT and IoS, the adoption of glass as a resource has a relevant aspect to be considered. The incidence of the daylight straight on the glass walls, which would demand a very efficient air conditioning system. The cities like Rio de Janeiro, where the temperature can easily reach 104° Fahrenheit, in these circumstances, the use of smart and sustainable technologies would be a solution. Lighting and temperature control make through the sensors. These sensors capture the light and temperature intensity over glassy materials and automatically send a message for the structures to adjust heat and lighting. The lighting control of the glasses by sensors that inform how much lighting can be reduced and how much heat should be blocked. Regarding environmental lighting, as previously mentioned, intensity control devices located on the walls of each unit allow for the control the amount of light needed.

The lighting adjustment should base its structure on the kind of activity to be performed in each building of healthcare institutions. The hospitalization area with patients resting is a good example. It would be feasible to have a panel with some basic commands like "rest," "ambulation," and "assistance." These commands would apply respectively when the patient is resting (dim lights), when it is necessary to go to the toilet and walk around the room (moderate lights), and when the staff is performing any kind of assistance (full lights on). The next subsection, "the photovoltaic and smart technologies," shows the photovoltaic opportunities in addition to glass resources.

5.2.2. Photovoltaic and Smart Technologies

In addition to this concern, the proper use of natural resources and the use of disruptive technologies inserted by the fourth industrial revolution enable to implement sustainable projects and the cost reduction. Jannati and Nazarpour [74] approach a model to attempt the environmental and economic dimensions for electric vehicles parking lots on a recent study. The photovoltaic panels are presented as one of the alternatives for these parking spaces. Comparing the parking spaces to healthcare institutions, the use of these panels brings benefits for environmental, social, and economic aspects.

The IoT brings development for the healthcare institution daily routine, since it is integrated into the construction process, as well as the restructuring of the projects and the processes. In this sense, the IoT helps to lead sustainable practices, endorsing the connection with the triple bottom line and disruptive technologies [75]. It is important to highlight that both concepts allow the circular economy

to perform its goals on this supply chain, allowing the transformation, the recycling [76], and the reusing [11]. Bradley et al. [77] propose a model that determines the placement of the resources in a closed recovering system, which is, recycling, reducing, and reusing on its study. They also mention the innovation and the green decision making on this process. In order to stimulate the green decision making, "water management and smart technologies" presents the water concern.

5.2.3. Water Management and Smart Technologies

On healthcare institutions day by day, some actions have a significant impact on the economy with the implementation of simple measures. These measures, as closing the taps during some processes and the maintenance of those activated by the sensors, represent a significant change. The reuse of the water, in case of the toilets, is applied and tends to increase even more, by getting new users of this practice. The water resource and the wastewater treatment are some aspects discussed in Abu-Ghunmi et al. research [78].

The use of the sensors is another resource widely used in many buildings around the city, and which can be implemented on a larger scale, in possible the healthcare institution sites. Likewise, healthcare institutions management of the water use integrated into the IoT (the sensors, the software, and the people). This integration allows the opening of the pluvial water reservoirs, placed in safe locations with the aim of capturing and storing rainwater. In this case, the water from this reservoir would not pass by the roofs and the floor. The sensors might help the opening of slots in wells to receive pluvial water. The reuse of the wastewater in the urban areas is discussed by Marteleira et al. [79].

The implementation of the new work routines and proposals requires a cultural and behavioral change. As an example, it is common, in the surgical center unit, the professionals to leave the tap open while washing hands before surgical procedures when the device is a common tap, forgetting to close it by the end of the hygiene process. It is estimated that this procedure lasts from two to five minutes using common taps. On the other hand, when the sensors system is placed, the tap is open only while necessary, reducing water waste.

The authors bring as a contribution to further research study the following hypotheses. These hypotheses are a way to future researches and provide a reflection about sustainable practices together with disruptive technologies:

Hypotheses B:

Hypothesis B1. *Sustainable practices, strengthened by the circular economy, together with disruptive technologies, can help healthcare institutions to contribute to enhancing the SDGs.*

Hypothesis B2. *Smart technologies, when implemented with sustainable practices, can allow the time and cost reductions and can enhance CSR and the healthcare institutional brand.*

Hypothesis B3. *The healthcare institutions can positively impact society by influencing and sharing their practices in order to achieve the SDGs.*

Hypothesis B4. *The healthcare institutions can offer educational support to their employees in order for the employees to be able to use smart technologies.*

Hypothesis B5. *The employees of healthcare institutions can try to adapt and to understand smart technologies in order to improve their careers.*

The circular economy transitions conceptual framework with the corporate social responsibility mirror.

The integration between the circular economy and Industry 4.0 allows the management and the implementation of the actions. This integration aims the optimization of natural energy use, sustainable resources, and water management inside the healthcare institution. The IoT, inserted on the healthcare

unit project, establishes the connection for adjustments and better use of natural resources. As an example, the use of the sensors in glass walls to control the daylight incidence, being previously programed to receive and control the intensity of solar energy, enabling the smart use and the comfort of it. The pellicles put on glasses could perform the same function, but its main goal would be to reduce the temperature inside the rooms with lower heat absorption. The IoT also has the role to spread sustainable practices. The apps that guide employees and the local community on how to use natural resources wisely, like free flow of the water while showering and doing the dishes, collecting of rainwater to be used as toilet flushing. These are a stimulus to make and to spread these practices in the community. The sites and social network profiles may also inform about new practices done by the healthcare institution. It allows the elevation of the brand and the ethical pattern, enabling the community to see, and realize that the healthcare institution as an acting partner on the contexts in which they are located.

Regarding the staff, online games and training sessions can be elaborated in order to provide better connectivity on sustainability and Industry 4.0. The internal disclosure of the actions creates a sense of value and pride from the professionals, since they are part of a company with ethical concepts and global vision. This is some of CSR role and it can create a mirror that reflects the good examples for other healthcare institutions. Figure 4 presents the circular economy transition conceptual framework, which highlights how CSR and smart technologies implement the responsible natural resource use.

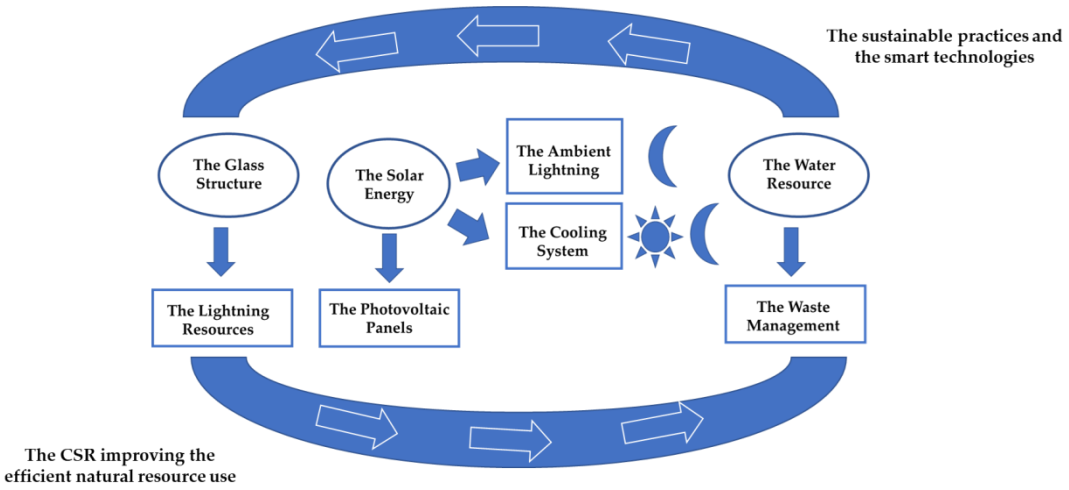

Figure 4. The circular economy transition conceptual framework with the corporate social responsibility mirror.

6. Conclusions

This research study has presented the importance of the social responsibility for the sustainability in the healthcare supply chain, as well as has shown how disruptive technologies can contribute to the achievement of the SDGs in the triple bottom line. The linear concept goes through changes that allow the reach of the circular concept. What comes next is a concept of the resource's extraction, as previously shown here by natural resources, like solar energy and water. The integration between the triple bottom line and Industry 4.0 allows the transition from the linear concept to the circular economy concept. The production and the generation of the material used, its use, its return to the residue condition, and its transformation into another stage, are cycles that enable their reproductions as many times as possible. Because they are cycles, they might be transformed, reproduced, and recyclable. The practices that are established and shared by CSR complete the purposes for the acceleration of the global movement towards the reach of the 17 SDGs established by the UN in 2015 for the year 2030.

The authors of this study established questions that guided the present research study, from the common world concern about sustainable development. Does the supply chain from the circular economy perspective attend the requirements of the sustainable supply chain? How does Industry 4.0

influence the circular supply chain? What are the expected results with CSR implementation in the sustainable supply chain?

In order to answer these questions, the authors propose the circular economy transition conceptual framework with the corporate social responsibility mirror. The term transition was incorporated as a way to characterize the change from the linear to the circular economy.

The rational use of natural resources by the putting of glass instead of brickwork enhances the use of sunlight for environmental lighting. The fourth industrial revolution integrates this framework with the sensors that allow the environmental lighting and heat control, to which pellicles could be used in addition to the sensors. The triple bottom line brings up the environmental issues, as well as the cost reduction and the staff comfort while at work on healthcare institutions. The social concern can also be observed and attended, by the shielding of the hospital glasses, besides the privacy character it brings to patients, its family members, and the healthcare staff. The solar energy stored in the photovoltaic panels allows the reduction of the artificial lights through its storage for the day and night use. The other point is the reuse of the pluvial water and the educational programs for the conscious use of the water. The IoT and the IoS help by corroborating one more stage.

CSR allows the circularity of the healthcare supply chain. It enables sharing and replicability of the practices so that other healthcare institutions may have it as a corporative example. After that, a new supply chain takes place, the so-called healthcare sustainable supply chain 4.0, bringing circularity to the process and contributing to reaching the global goals. New studies about the topic should be developed and stimulated, especially due to the tendency that is already present on the current publishing.

The authors of this study seek to encourage new research involving the healthcare supply chains with the insertion of sustainable practices and disruptive technologies. Additionally, a systematic search in the literature of good practices of the social sustainability in the sustainable healthcare supply chain is also recommended, as well as the positive effect analyses of these practices on the stakeholders' quality of life. This study has limitations regarding the analysis of a single healthcare institution, which also opens avenues for additional future research. More empirical studies should be conducted to analyze the replicability of the proposed conceptual model in other healthcare real-life settings aiming generalization of the research findings.

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