

SUSTAINABLE INNOVATION AND LEADERSHIP IN THE TREATMENT OF MEDICAL WASTE IN PORTO ALEGRE/RS

INOVAÇÃO E LIDERANÇA SUSTENTÁVEL NO TRATAMENTO DE RESÍDUOS DE SERVIÇOS DE SAÚDE EM PORTO ALEGRE/RS

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ABSTRACT

Purpose – The general objective of the research is to analyze an innovation in the Health Services Waste Management System (Medical Waste) and its importance for sustainable development in hospitals in Porto Alegre, capital of the state of Rio Grande do Sul (RS), Brazil, through the discussion of the concepts of sustainable innovation and sustainable leadership.

Design/methodology/approach – A qualitative case study was used as a research strategy, choosing an innovative entrepreneur in the development of technologies and management services for RSS, which already has two large hospitals as clients in Porto Alegre.

Findings – The research results showed the compatibilization of his MW managing solution with the concept of sustainable innovation. Furthermore, the entrepreneur showed to contemplate the guidelines for leaders in sustainability in their proposal of sustainable innovation, aiding his clients to transform their organizational culture, towards sustainability.

Research limitations/implications – As research limitations, it was not possible to visit hospitals, due to the pandemic caused by COVID-19, making it impossible to know the management of RSS in loco, nor interviewing environmental operators and managers.

Practical implications - In practical terms, the study showed that the internal treatment of MW is relevant in maximizing economic, environmental and social gains.

Social implications – The findings demonstrated a need for cultural change, on the part of hospitals, with regard to the treatment of MW.

Originality/value – The value of the study is the originality of innovation in the treatment of RSS and its great importance for sustainable medical waste management.

Keywords: Innovation. Leadership. Medical waste. Sustainability.

RESUMO

Objetivo – O objetivo geral da pesquisa é analisar uma inovação no sistema de gestão de Re-síduos de Serviços em Saúde (RSS) e sua importância para o desenvolvimento sustentável em hospitais de Porto Alegre, capital do estado do Rio Grande do Sul (RS), Brasil, através da discussão dos conceitos de inovação sustentável e liderança sustentável.

Desenho/metodologia/abordagem – Utilizou-se como estratégia de pesquisa o estudo de caso qualitativo, escolhendo um empreendedor inovador no desenvolvimento de tecnologias e serviços de gestão para RSS, que já possui dois grandes hospitais como clientes em Porto Alegre.

Resultados – Os resultados da pesquisa demonstraram a compatibilização de sua solução de gerenciamento de RSS com o conceito de inovação sustentável. Ademais, o empreendedor demonstrou contemplar as diretrizes para líderes em sustentabilidade em sua proposta de inovação sustentável, auxiliando seus clientes a transformarem sua cultura organizacional, em direção à sustentabilidade.

Limitações/implicações da pesquisa – Como limitações de pesquisa, não foi possível visitar os hospitais, em razão da pandemia causada pela COVID-19, impossibilitando conhecer o gerenciamento de RSS in loco, tampouco entrevistando os operadores e gestores ambientais.

Implicações práticas – Em termos práticos, o estudo mostrou que o tratamento interno do RSS é relevante na maximização dos ganhos econômicos, ambientais e sociais.

Implicações sociais – Os achados demonstraram uma necessidade de mudança cultural, por parte dos hospitais, no que se refere ao tratamento de RSS.

Originalidade/valor – O valor do estudo está na originalidade da inovação no tratamento de RSS e sua grande importância para a gestão sustentável de RSS.

Palavras-chave: Inovação. Liderança. Resíduos de serviços de saúde. Sustentabilidade.

1 INTRODUCTION

The solid residue management constitutes a great challenge for cities because expressive amounts of waste are generated daily in the urban environment, which can cause serious impacts on public health and environmental quality. Through a survey in cities and companies from the health sector, the national projection from the Brazilian Association of Urban Cleaning and Special Waste Management Companies (ABRELPE) showed, in 2019, that the volume collected in the country was 253.000 tons of Medical Waste (MW), representing 1.213 kg per inhabitant/year (ABRELPE, 2020).

Thus, effective actions are demanded from the public power, private organizations and citizens, through a shared responsibility, seeking solutions for the solid residue management, in particular MW, under the premise of sustainable development. To discipline solid residue management, one of the great regulatory landmarks in Brazil was the Federal Law nº. 12.305/2010, which institutes the National Policy for Solid Residues (NPSR). In this federal legal instrument, it is expressed the need to take sustainable development into account in the integrated solid residue management, observing a set of actions seeking solutions, which contemplate the political, economic, environmental, cultural and social dimensions, with social control (Brazil, 2010). Therefore, in the issue of solid residue management, it is noted the incorporation of the discussion of sustainable development in its multiple dimensions.

The MW can present medications with several chemical substances, as well as potentially infectious biological material, representing risk to cities' public health and environmental quality if the waste is not properly treated. According to ABRELPE (2020), the predominant final destination for MW collected by the cities is incineration (40.2%), followed by autoclave (18.5%) and microwaves (5.1%). It is worth highlighting the 'others' category (36.2%), which corresponds to the disposal, with no previous treatment, in landfills, septic ditches, dumps, etc., going against the appli-

cable legislation that establishes treatment before final disposal for certain MW groups and presents direct risks to workers, public health and the environment (ABRELPE, 2020). Consequently, there is a demand for managers that lead the elaboration of new solutions for the MW problem in medium and large hospitals. In this situation, the concepts of innovation and leadership need to be aligned with sustainable development (UN, 2004, 2015a, 2015b; Barbieri *et al.*, 2010; Arnaud & Sekerka, 2010; Ottosson, Moldavska, Ogorodnyk, & Skogsrød, 2017).

In Porto Alegre, capital of the state of Rio Grande do Sul (RS), Brazil, an entrepreneur develops avant-garde technologies and managing services for MW, who already has two no-table hospitals in this city using his innovation. In the news report “Waste cycle and recycling in Moinhos de Vento Hospital”, shown in the program “Cities and Solutions”, from *Glo-boNews* (2017), your MW management experience is considered unique in Brazil. In this context, the following research question emerges: what types of innovations and how are they being incorporated in the MW managing system, through the prism of sustainable development? Thus, the main objective of the present research is to analyze one innovation in the MW managing system and its importance for sustainable medical waste management, through the discussion of the concepts of sustainable innovation and sustainable leadership, and considering three specific objectives:

1) Observe if the proposed innovations on MW managing can be considered sustainable innovations;

2) Verify the perception of manager of the MW company in relation to the clients’ acceptance of his innovation proposals.

3) Investigate if the creator of the innovations on MW managing has the characteristics of sustainable leadership;

In order to do that, a qualitative case study was carried out with an entrepreneur that develops avant-garde technologies and managing services for MW, in Porto Alegre/RS. Due to the relevance of this technology and management model, it is important to analyze this emerging innovation in the treatment of MW, as well as the role of leadership in this process, which indicates the originality of this study for sustainable medical waste management. Furthermore, it is noteworthy that the case under study is present at Hospital Moinhos de Vento, which is among the 100 best hospitals in the world (Newsweek, 2021), and at Santa Casa de Misericórdia, the largest hospital in Rio Grande do Sul (brazilian state with a higher number of hospital beds, proportionally) (Atlas Econômico do Rio Grande do Sul, 2020), which demonstrates the relevance of the initiative. Krüger, Araújo & Curi (2017) found as results a natural hierarchy of environmental priorities in hospital management, and the present qualitative case study can help to understand how hospitals can improve their environmental performance through sustainable innovation and leadership.

The article is structured in 4 items. After this introduction (1), the theoretical framework (2) is presented, contemplating aspects relative to innovation and sustainable leadership, and MW. Then, the method used is shown (3) and the research results are presented and discussed (4). Lastly, there are the final considerations and the references that served as foundation for the study.

2 THEORETICAL FRAMEWORK

Here, a literature review carried out about innovation (specially, sustainable innovation with emphasis on institutional approaches and based on values) and about sustainable leadership, as well as information about the MW characteristics and legal aspects inherent to its management are presented.



2.1 SUSTAINABLE INNOVATION

The concept of innovation is one of the most fundamental for the dynamics of capital movement, with great implications for organizations. One of the great representatives of the discussion on innovation is Schumpeter (1985), who defines it as new combinations of knowledge, resources and equipment, which can result in the introduction of a new good, a new productive method, in the opening of a new market, in the conquest of new raw material source, or in a new organization. According to Baregheh, Rowley & Sambrook (2009), innovation is understood as the process that encompasses several stages in which organizations transform ideas in product, services or new/improved processes, in order to advance, compete and distinguish themselves with success in their market.

However, it is not enough to innovate, it is necessary that the innovations are sustainable, that is, that they take into account the finitude of resources and the planet's resilience capacity. Therefore, in 1987, through the report from the *World Environment and Development Committee*, entitled *Our Common Future*, the United Nations (UN) qualifies development as sustainable in a way that the current needs must be met without compromising the needs of future generations, since there was a great preoccupation regarding the speed of natural resources in relation to human environment, which also led to deterioration of social and economic development. Thus, the UN report manifests its preoccupation in relation to the awareness of governments' political decision-makers, intergovernmental and non-governmental international organizations, industry and other sectors of economic activity, as well as the general public, regarding the transition to a sustainable development (UN, 1987).

Thus, in 2015, the document "Transforming Our World: the 2030 Agenda for Sustainable Development" was approved, contemplating the legacy of the Millennium Development Objectives, whose eight objectives should have been reached until 2015, and seeking to take bold and transformative measures to put the world in a sustainable and resilient path with its new 17 Sustainable Development Objectives (SDO). For example, in the article's discussion, the SDO 9 is highlighted, which seeks to build resilient infrastructures, promote inclusive and sustainable industrialization and instigate innovation (UN, 2015a).

Due to the important role of companies as political, social and economic institutions in global society, inseparably connected to daily life, Arnaud & Sekerka (2010) attribute them great part of the responsibility of guaranteeing sustainability of the planet's resources. From the sustainable development discussions in the last decades, new approaches also emerged in the field of administration for innovation, such as eco-innovation and sustainable innovation.

The *Oslo Manual* presents innovation as the implementation of a new or improved product (good or service) in a significant way, or a process, or a new marketing method, or a new organizational method in business practices, in local work organizations or external relations (OECD, 1997). Based on this definition, Kemp & Pearson (2007) understand eco-innovation as the production, assimilation or exploration of a product, production process, service or management or business method that is new to the organization, both developing or adopting it, and it results, throughout its life cycle, in reduction of environmental risks, pollution and other negative impacts of using resources, including energy, compared with pertinent alternatives. Another concept elaborated by OECD itself defines eco-innovation as the creation of new or significantly improves products (goods or services), processes, marketing methods, organizational structures and institutional arrangements, which – with or without intention – lead to environmental improvements in comparison to relevant alternatives (OECD, 2009).



Due to negative impacts that, in general, accompany innovations, such as pollutants emissions and depletion of human resources, Barbieri *et al.* (2010) point out that Kemp & Pearson's (2007) definition of eco-innovation emphasizes the reduction of problems, pre-supposing that the economic benefits will be perceived in some way. For Barbieri *et al.* (2010), it is also perceived that eco-innovation refers to eco-efficiency, which is situated in the inter-section of two sustainability dimensions, the economic and the environmental. According to Godoy-Durán, Galdeano-Gómez, Pérez-Mesa & Piedra-Muñoz (2017), eco-efficiency is a sustainable concept emerged in 1990s and means "the relationship between economic and eco-logical efficiency, is a useful indicator in relation to the capacity of companies, sectors and economies to produce goods and services with less consumption of natural resources and less impact on the environment" (p.594).

Barbieri *et al.* (2010) consider that eco-efficient innovations are, for example, the ones that reduce the amount of materials and energy per produced unit, eliminate toxic substances and increase product shelf life, however, they can generate unemployment, destroy competences, harm communities or segments of society, among other social problems. In light of that, in these authors' understanding, the social dimension should be present explicitly, for eco-efficient innovation to also be sustainable innovation. Thus, they define sustainable innovation as the introduction (production, assimilation or exploration) of products, productive processes, management or business methods, new or significantly improved for the organization and that brings economic, social and environmental benefits, compared with pertinent alternatives. In the construction of the concept, these authors analyzed the relation between sustainability and innovation, using the Institutional Theory as reference, defining sustainable innovation from a historic dimension of the evolution of the sustainable development movement and its institutionalization.

Another vision that contributed to the theoretical discussion of sustainable innovation is proposed by Arnaud & Sekerka (2010). According to the authors, although the regulations encourage innovation for sustainability, there is a limitation in the actions of the organization, since they are forced to prevent, detect and punish violations, instead of motivating innovation through shared organizational values, attitudes and practices. In the climate proposal for sustainability, Arnaud & Sekerka (2010) list (2009) four fundamental dimensions: (1) moral sensitivity to sustainability, which involves the collective sensitivity of the organization's employees in relation to ecological sustainability; (2) moral motivation for sustainability, which refers to the predominant organizational values, shared lasting beliefs of what is desirable, which promote ecological sustainability; (3) moral judgment of sustainability, which is about the norms of moral reasoning used to determine which course of action is morally solid and ecologically sustainable; and (4) responsibility for sustainability, which is defined by the general level of responsibility that the organization (as shown by its employees) takes for the well-being of all living being and nature.

Thus, Arnaud & Sekerka (2010) propose that an approach based on values, such as climate for sustainability, deeply introduces sustainability in the organization and, probably, will have a positive and lasting influence in innovation for sustainability. Arnaud, Tinoco & Rhoades (2013) carried out a survey regarding the climate for sustainability, through three factors: sensitivity to sustainability, motivation for sustainability and responsibility for sustainability. In the research results, the referred authors verified that the climate of sustainability is positively related to innovation strategies, including product innovation strategies and innovation strategies for conservation.

In turn, according to Ottosson *et al.* (2017), neither "sustainable development" nor "innovation" is a well-defined term, proposing to describe what "sustainable innovation" is and how it develops, through the following definitions:



A sustainable solution is a solution that has been developed to be a long-lasting, environmentally responsible solution for the provider (the business), the society and the users. An innovation is a new solution that has been 'sold' and is used by more than one user or that is used in at least one-use situation. The innovation process, carried out as an innovation project, contains all stages from idea generation, development (R&D) and commercialization to an implemented solution on the market (Ottosson et al., 2017, p. 206).

Thus, the cited author (2017) advocates the development of the product as the most important aspect of the development of new sustainable innovations. The result of a product development project is based on the knowledge, experience and skill of the product developer, and the leadership of an entrepreneur is vitally important to the level of sustainability of an innovation. Therefore, product developers and entrepreneurs need to be educated in a broader perspective than that which is common in the technical field today (Ottosson *et al.*, 2017). In this direction, one important author in the process of sustainable innovation is the leader that believes and guides their behavior in the concept of sustainability.

2.2 SUSTAINABLE LEADERSHIP

In recent decades, society has put pressure on organizations to be responsible leaders for sustainability. According to Avery & Bergsteiner (2011), sustainable leadership encompasses aspects of humanistic management, in the sense that people are valued and the company is seen as a contributor to the social well-being, forming a self-reinforcing leadership system that improves the performance of a business and its perspectives of survival. In the UN sphere, in a report entitled *Globally responsible leadership: a call to engagement*, the Global Pact Program stated that the globally responsible leadership in the 21st century is guided by the exercise of ethical leadership and based on values, seeking economic and social progress, and sustainable development. This vision is guided by the essential comprehension of the interconnection of the world and the recognition of the need for economic, social and environmental advances (UN, 2004).

For the UN Global Pact, globally responsible leaders need to face four key challenges: 1) think and act in a global context; 2) magnify the corporate purpose so that it reflects accountability in all society globally; 3) put ethics at the center of their thoughts, words and actions; 4) transform the executives' education to put the global corporate responsibility at the center. Thus, the guiding principles of justice, freedom, honesty, humanity, responsibility, solidarity, sustainable development, tolerance and transparency are highlighted as some of the starting points for a globally responsible leadership (UN, 2004). In addition, article 67 of the 2030 Agenda promotes a call to action for companies to use their creativity and innovation to solve the challenges of sustainable development (UN, 2015a). In the SDO guide for companies in the UN Global Pact, it is emphasized the importance of the leading companies' role in showing how their businesses help the SDO global agenda (UN, 2015b).

In this context, Schein (2017) considers psychological and emotional development as the most importance capacity for leaders to develop, including a higher awareness of deeper values, motivations and purposes. According to the mentioned author, the number of executives that daily defend sustainability initiatives is surprisingly low and, although much has been written about their accomplishments, there is not enough knowledge about their personal histories, their deepest motivations and how they think about nature, leadership, resistance and change. To change the current paradigm, Schein (2017) proposes a new psychology for leadership in sustainability, integrating eco-sciences to the business curriculum, with a larger development focus on the leaders of corporate sustainability.



Based on a research involving 1,584 companies, which represented 40 industry sectors and 107 countries, the *United Nations Global Compact Progress Report 2019* report showed that 71% of CEOs (Chief Executive Officers) recognize the critical role that businesses can have in contributing to the achievement of the SDO, however, only 32% of CEOs indicate that their company has or plans to establish sufficiently ambitious corporate goals, based on science and aligned with society's needs. The report still revealed that only 21% of the CEOs believe that businesses are really performing this role, as well as 25% of companies have corporate goals that adequately support society's objectives. Furthermore, only 35% of CEOs stated that the companies' actions to support the SDO are aligned with a larger commercial strategy, as well as 39% said that their products and services or business models significantly influenced the SDO (UN, 2019).

It is also worth highlighting, in the *United Nations Global Compact Progress Report 2019*, the levels in which corporate responsibility policies and strategies are developed and/or evaluated. The companies report that they are developing and evaluating corporate responsibility strategies in several levels: CEO (67%); Senior Management (50%); Board of Directors (44%), Corporate Responsibility or Ethics Officer (41%); Middle Management (21%) (UN, 2019). Thus, the most reported level of development and/or evaluation of corporate responsibility policies and strategies was the CEO.

Hallinger & Suriyankietkaew (2018) conducted a research review, employing scientific mapping tools to examine 952 Scopus-indexed documents explicitly concerned with sustainable leadership. A synthesis of these conceptual definitions of sustainable leadership reveals a number of common features that cohere to distinguish this approach to leadership: emphasis on leadership, rather than a unitary leader; long-term vision; broader goals that link organizations to society; ethical behavior; social responsibilities of leaders and organizations; innovation capacity; systemic change; stakeholder engagement; and capacity building of stakeholders (Hallinger & Suriyankietkaew, 2018). In this context, sustainable leadership can be a key piece for organization to achieve the SDO.

2.3 MEDICAL WASTE MANAGEMENT

MW have a wide variety of characteristics, resulting in different classifications and degrees of danger. According to the Resolution from the National Environmental Council (CONAMA) Nº 358/2005, MW are classified in five groups according to their characteristics: Group A (residues with possible presence of biological agents that, due to their characteristics of higher virulence or concentration, can present risk of infection); Group B (residues containing chemical substances that can present risk to public health or the environment, depending on their flammability, corrosivity, reactivity and toxicity characteristics); Group C (any material resulting from human activity that contain radionuclides in higher amounts than the elimination limits specified in the National Nuclear Energy Committee – CNEN norms and for which reutilization is unsuitable or not foreseen); Group D (residues that do not present biological, chemical or radiological risk to health or the environment, it can be equated to household residues); Group E (sharp or scarifying materials) (Brazil, 2005).

In the city of Porto Alegre, data from the City Department of Urban Cleansing (DMLU) indicate an estimated population of 1,412,135 inhabitants, in 2011, generating 1,786 tons of Solid Urban Residue (SUR), which corresponds to a per capita generation of 1.27 kg per inhabitant/day (DMLU, 2013). Regarding MW, belonging to Group D, the DMLU estimates the generation of 19.45 tons per day in 2011 (DMLU, 2013). Taking into account a generation of 1786 tons of MW in the city of Porto Alegre, approximately 1.08% of MW classified as D is generated daily from the total SUR. According to the National Health Surveillance Agency (ANVISA), despite the MW composing approximately 1% to 3% of the total SUR, such residues are important in the total SUR reckoning due to the potential



risk to health and environment (Brazil, 2006).

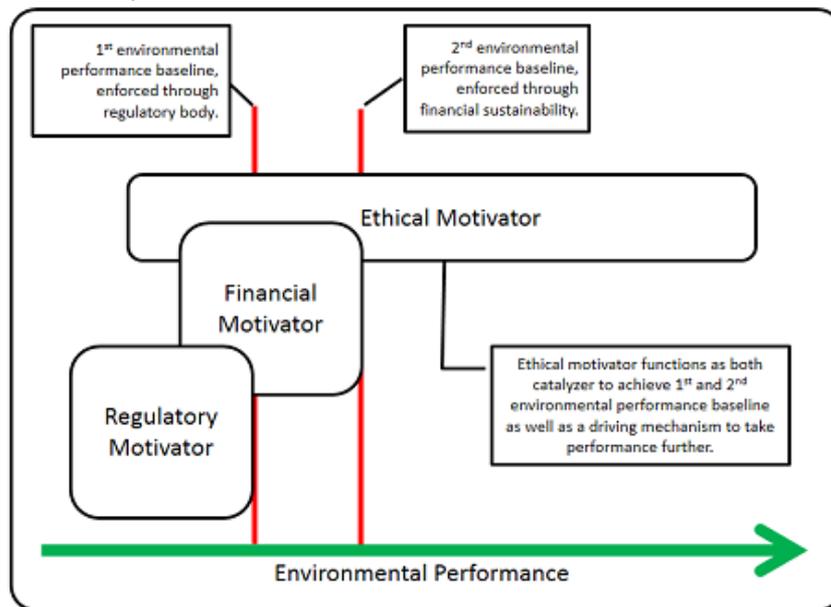
When not treated, the medical wastes can be harmful for the environment and for human health. Among the negative impacts that occur from the lack of proper treatment are: contamination of rivers and groundwater that can lead to an epidemic of infections (Cafure & Patriarcha-gracioli, 2015; Rodriguez-mozaz *et al.*, 2015); risk of biological contamination by virus, bacteria and fungi; radioactive contamination (Bolisetty, Coray, Palika, Prenosil & Mez-zenga, 2020); resistance to anti-biotics by people who consumed contaminated water; feminization of male aquatic animals (Morais *et al.*, 2012); contamination of garbage collectors, people who work with recycling and health professionals (Acharya, Gokhale & Joshi, 2014); increased contagion of infectious diseases as COVID-19 (Bucătaru *et al.*, 2021).

Other fundamental definitions of the NPSR are the shared responsibility for the products' life cycle, involving a set of individualized and chained attributions among the several actors, and the reverse logistics, characterized as an instrument of social-economic development in the process of collection and restitution of residues to the business sector (Brazil, 2010). In the case of MW, the NPSR determines the elaboration of the Solid Residue Management Plan for the generators of these solid residues, defining a minimal content to be obeyed by the companies, being considered an integral part of the company's or activity's environmental licensing process by the competent organ of the National Environmental System – SISNAMA (Brazil, 2010). These directives are in accordance with the CONAMA resolution Nº 358/2005, which predicts, for example, the elaboration of the Medical Waste Management Plan (MWMP), according to the current legislation, specially the health surveillance regulations, and the definition of criteria to determine which services will receive environmental licensing, which should appear in the MWMP (Brazil, 2005).

In addition to the NPSR defining sustainable development as one of its principles, it is also highlighted the connection of the MW management theme with the sustainability of cities. According to Law Nº 10.257/2011, called City Constitution, urban policy must guarantee the right to sustainable cities, considering the right to urban land, housing, environmental sanitation, urban infrastructure, transport and public services, work and leisure, for present and future generations (Brazil, 2001). Therefore, in the City Constitution, it is verified a direct relation between the right to sustainable cities and the right to environmental sanitation, which has solid residue management as one of its pillars.

In this context, hospitals are organizations that generate a large amount of MW, requiring an adequate management of this waste. In a multiple case study involving four Brazilian hospitals based in Rio de Janeiro and São Paulo, Krüger, Araújo & Curi (2017) find as results that the main motivating factors in hospital environmental management programs are competitive, ethical and regulatory. Figure 1 shows the results of the interviews carried out in this study:

Figure 1 - Proposed Motivator/Performance Model



Source: Krüger, Araújo & Curi, 2017, p. 504.

In this research, the regulatory motivator is the first performance baseline and is heavily dependent on the state; the competitive motivator represents the second baseline and showed to be limited to financial concerns, but private and public hospitals might contrast in terms of the importance of this performance baseline; and ethical motivator can be seen as a catalyzer to achieve the previous baselines and can be a mechanism to take performance further, because if the society as a whole does not approve a given ethical posture, the organization will then face a legitimacy vacuum and/or suffer from a lack of customers (Krüger, Araújo & Curi, 2017).

In a mini review about the hospital waste management in developing countries, hospitals in these countries suffer from poor waste segregation, collection, storage, transportation and disposal practices, which can lead to occupational and environmental risks, and sustainable waste management practices can help a lot in reducing the effects hazardous waste from hospital waste (Ali *et al.*, 2017). Krüger, Araújo & Curi (2017) found as results a natural hierarchy of environmental priorities in hospital management, with the first priority being the correct handling of waste, followed by waste reduction and then efficiency in the use of resources. A further stage of actions, called "Green Investment", involves greater financial/resource investment, extensive training and advanced equipment. More elaborate strategies (upstream environmental, supplier development for environmental products, change of procedures, lobbying for more comprehensive regulation, extensive benchmarking) are of a higher nature in this hierarchy (Krüger, Araújo & Curi, 2017). Thus, it is pressing that a new type of innovation and leadership in order to have solutions related to Sustainable Medical Waste Management and achieve its objectives.

3 METHOD

To understand the proposed research question, a qualitative case study was used as research strategy, choosing an innovative entrepreneur in the development of MW managing technologies and services, in Porto Alegre/RS. According to Yin (2014), the case study involves an empirical investigation of a contemporaneous phenomenon in its real-life context, specially when the limits

between the phenomenon and the context are not clearly evident.

The choice of this case study is important, since the chosen entrepreneur is a pioneer in the creation of MW managing technologies and services in the country, with his managing technologies and services already in two large hospitals in Porto Alegre. As emphasized in the news report “Waste cycle and recycling in Moinhos de Vento Hospital”, shown in the program “Cities and Solutions”, from GloboNews (2017), the MW management experience is unique in Brazil. Thus, this study sought, through the case study, to understand how this unique innovation in Brazil can contribute to waste management, through the theoretical lens of innovation and sustainable leadership. Furthermore, the use of these innovation by hospitals to treat MW has a large repercussion for the Sustainable Development of cities and the MW management.

According to Yin (2014), the case study is based on several sources of evidence, the data needing to converge in a triangle, as well as it benefits from the previous development of theoretical propositions to carry out data collection and analysis. In this direction, in the elaboration of the present article, primary and secondary data were used to acquire evidence and, then, triangulation.

The primary data were collected through two interviews with the owner and administrator of the company of sustainable solutions for medical waste. The first interview was exploratory and was conducted openly, on July 25th, 2019, lasting approximately one hour, in Porto Alegre. This initial interview helped in the elaboration of the research question, the objectives, the theoretical framework and the scripts for the second interview.

The second interview was semi-structured, it occurred in April 24th, 2020, online, also in Porto Alegre, and lasted 2 hours and 2 minutes, being recorded and transcribed in full. The interview scripts were elaborated based on the general and specific objectives and on the theoretical framework. It is also worth highlighting the elaboration of wider questions about the entrepreneur and his organization, which followed scripts based on the theoretical framework, during the interview. The secondary data collected were: documents provided by the entrepreneur; information present on the website of the hospitals for which the company works; data from the website of other national companies that work with MW. Figure 2 summarizes the relation among interview script, objectives, theoretical framework and data collected:



Figure 2 - Relation among interview script, objectives and theoretical framework.

Specific Objectives	Theoretical Framework	Interview Scripts	Data Collected
1) Observe if the proposed innovations on MW managing can be considered sustainable innovations;	Barbieri <i>et al.</i> (2010); Ottosson <i>et al.</i> (2017); Krüger, Araújo & Curi, 2017.	Script (1) – Sustainable Innovation	- Initial and second interview; - Documents provided by the entrepreneur; - Data from the website of other national companies that work with MW.
2) Verify the perception of the MW company's manager in relation to the clients' acceptance of his innovation proposals;	Arnaud and Sekerka (2010); Barbieri <i>et al.</i> (2010); Krüger, Araújo & Curi, 2017.	Script (1) – Sustainable Innovation	- Initial and second interview; - Information present on the website of the hospitals for which the company works
3) Investigate if the creator of the innovations on MW managing has the characteristics of sustainable leadership.	UN (2004); UN (2015a); UN (2015b); Hallinger & Suriyankietkaew (2018).	Script (2) – Sustainable Leadership	- Initial and second interview; - Documents provided by the entrepreneur; - Data from the website of other national companies that work with MW.

Source: Elaborated by the authors.

The collection of secondary data from competing companies and from the entrepreneur's client hospitals will help to complement the understanding context and the importance of the proposed innovation for sustainable medical waste management, avoiding the bias of the entrepreneur's view alone. After data collection, the transcript of the second interview was inserted in the

Nvivo12 software, for analysis through categorization process (Bardin, 2011), with the codes subdivided based on the theoretical framework brought up in the research (theory driven): sustainable innovation and sustainable leadership.

4 RESULTS AND DISCUSSIONS

The results and discussion start with the treatment of the second interview, using the Nvivo12 software. Through this software, the data of the interviewee were analyzed, producing the following word cloud, grouping with stemmed words (Figure 3):

Figure 3 - Interviewee's word cloud.



Source: Elaborated by the authors.

From this initial result, we sought to analyze the meanings of the words in the context of the codes created through the theoretical framework. For example, we tried to comprehend, in the data analysis and highlighted words, how the entrepreneur creates innovative “managing” “processes” to deliver a “sustainable” “solution” to his “clients” and “solve” specially in the “environmental” issue of “waste” “problem”, and his perception about the acceptance of this “business” proposal by the “directors” of the “hospitals”. Then, the results and discussion are divided in three topics: general information and context of the organization, sustainable innovation and sustainable leadership. The highlighted words are discussed in the sections in the word cloud are discussed in the analysis on innovation and sustainable leadership.

4.1 GENERAL INFORMATION AND CONTEXT OF THE ORGANIZATION

Before the creation of the MW managing company, it is highlighted the entrepreneur's wide experience in the solid waste field in the last twenty years. In his academic resume, he showed interest in the industrial field, graduating, at the same time, as a mechatronics technician and company administrator, and continuing to a graduate program in company management.

In his undergraduate thesis in Administration, he developed a high-density polyethylene recycling project in bottles, for example, bleach bottles, which was put in practice by a university classmate, who has the means to invest at the time. In this period, he worked in the information and

management technology field in a company located in Caxias do Sul – RS. Then, in 2003, he founded his own plastic recycling and processing company, through the granulation and extrusion processes, thus becoming a recyclable plastic supplier for companies in the region.

Due to the financial of 2008 and other aspects, the entrepreneur closed his company. After, he had another significant experience in the solid waste field, with the development of plastic wood products, by the process of plastic composition with rice husk, through a society established in the beginning of the decade of 2010. A great example of this work was the construction, through recyclable plastic, of a sustainability shed, for Braskem, a large company in the petrochemical sector, manufacturer of plastic resins, during the “Farroupilha Encampment”, traditional cultural event that occurs in Maurício Sirotski Sobrinho Park (Harmony Park), in Porto Alegre.

In this occasion, he met a member of the Brazilian Sanitary and Environmental Engineering Association, responsible for the event’s environmental education project “Conscious Harmony”, who also belonged to the environmental management committee of the Hospitals and Clinics Syndicate of Porto Alegre. In a troubled time in relation to MW, with hospital being fined, the committee discussed possible solutions for the sector in the beginning of the decade of 2010. In this situation, the entrepreneur was invited to participate in the discussions, and he managed to visualize a solution for the problem and a business opportunity. Thus, in 2013, he began negotiating with Moinhos de Vento Hospital, in the city of Porto Alegre, and, in 2014, he opened his new company in order to receive this contract, thus entering in the hospital field of waste management.

In addition to the Moinhos de Vento Hospital, the entrepreneur also managed to get another contract with the Santa Casa de Misericórdia Hospital of Porto Alegre, in 2015. According to institutional documents available in the hospitals’ websites, Moinhos de Vento Hospital is a technological reference in medical, assistance and management practices, currently having 3,395 doctors and 472 beds. In turn, the Santa Casa de Misericórdia of Porto Alegre is the oldest hospital in RS, being recognized as one of the most modern hospital complexes in the country, having 2,600 doctors and 1223 beds. In addition, the entrepreneur had his project approved in another large hospital in the capital (Clinics Hospital of Porto Alegre), and is prospecting other client outside RS.

Aware of the difficulties he had, such as costs from collaborators and infrastructure in his previous experiences, the current company is a startup, which works in a hub format, as described by the entrepreneur:

So, I modeled the business, I have domain of the project and the system how it has to work. For each part of the business model that we have, I have an actor, someone that executes something. So, I have a machines and equipment designer, who is hired by job, I have a engineering team, which is hired by job, I have a logistics operator for the collection of recyclable waste and to make the transformation, also by job, (...), as I close contracts, he jumps into action and execution. I have industries that are already hired partners to make the transformation of paper into toilet paper, plastic into garbage bags, and other that we are expanding now (E1).

The company has, in the year 2020, two standing contracts, which allows it to invest in the development of new technologies and services. Furthermore, the entrepreneur expects the acceleration of this startup through a partnership with the Moinhos the Vento Hospital.

This subsection highlights the importance of the entrepreneur’s academic and professional trajectory to create his proposition of sustainable innovation, in line with the Ottosson et al. (2017), who calls attention to the knowledge, experience and skill of the product developer, and the importance of leadership for the level of sustainability of an innovation, requiring training that goes beyond the technical field. That said, the solution developed by the entrepreneur for his clients will

be detailed and analyzed, verifying his innovation proposal in the context of sustainability.

4.2 SUSTAINABLE INNOVATION

In this subsection the characteristics of the proposed innovation by the entrepreneur and its comparison with the traditional solution of competing companies are discussed, in the context of the sustainability of waste management. According to Figure 3, the words “Solve”, “Solution”, “Treat”, “Environmental”, “Processes” were mentioned many times by the inter-viewee in his explanation about the “Boomerang Method”, on which his service is based to solve the “Problem” of “Waste” in “Hospitals”:

(...) our main objective was always: we want to deliver the solution, that is, take this, install it and from here on you will have autonomy. And this was the objective of the boomerang. (E1)

It is worth clarifying the difference of the solution proposed by the entrepreneur for MW management, that is, in his words, “we had already set as premise (...) that we should move the least possible of the residues for it to really be a solution (E1)”. Different from the traditional methodology, which is based on sending MW to other companies, the adoption of the “Boomerang Method” breaks from this standard solution, through distinguished treatment and managing processes in the hospital.

In the traditional methodology for the treatment of unserviceable biological and plastic waste, the hospital hires a company to collect the MW, which performs the decontamination in its own unit. Analyzing documents from a competing company, it is highlighted its proper fleet to carry out collection and transportation of medical waste in facilities that generate large or small amounts of waste. In another competitor, it is emphasized its global leadership in collection, treatment and final waste of health services available, serving hospitals, laboratories, medical and dental clinics, surgical centers, funeral homes, veterinary clinics and all establishments that generate waste of health services in groups A, B and E. In both companies and their presentations on their solutions for the treatment of health waste, sustainability is not mentioned.

Despite both solutions meeting the legal requirements for MW treatment, the service based on the implementation of the “Boomerang Method” is definitive and distinguished, with a significant decrease in environmental impacts due to its closed cycle operation. This characteristic is called “360° Management” by the entrepreneur, allowing, through the implementation service of the “Boomerang Method” and training, the operation autonomy by the hospitals. In this case, there is no responsibility transference in the MW management to other companies. The hospital itself being responsible by the operationalization of the processes.

The proposed innovation in the “Boomerang Method” can be framed in the stage called by the Krüger, Araújo & Curi (2017) as “Green Investment” (involves greater financial/resource investment, extensive training and advanced equipment) and more elaborate strategies (upstream environmental, supplier development for environmental products, change of procedures). Traditional technology, on the other hand, is at the beginning of the hierarchy proposed by Krüger, Araújo & Curi (2017), with the first priority being the correct handling of waste, followed by waste reduction and then efficiency in the use of resources. In the model proposed by Krüger, Araújo & Curi (2017), the higher levels of the hierarchy reached allow for better levels of environmental performance for hospitals.

In addition, the solution has the objective of meeting, together, the organizations’ environmental, social and economic expectations, through distinguished processes in MW management,

aggregating value to the hospital. Each internal process of residue management is modular and customizable for each client. In this moment, the company has a process focused on glass recycling, paper and cardboard recycling, plastic recycling, organic residue composting, and decontamination of unserviceable biological and plastic residue (for its transformation in energy cells). In the selling process of the product, the entrepreneur highlights these solutions and their economic, social and environmental gains, through a technical and economic diagnostic:

In the economic aspect, (...) medical waste is considered a dangerous residue, and it has the highest costs of residue treatment. Due to the high cost, we, treating it internally, are able to reduce 60 to 70% of the cost, because (...) there is the cost of equipment investment, there is the cost of the operation, energy, the operator, but you are still able to reduce it a lot. Environmentally, it will be impressive when we are able to make the perfect gasification, closed cycle. What happens is that we have to reduce all environmental impact (...) from its activity, which, in this case, is the residue. We don't have risk anymore, because it is being deposited in a landfill, it is not being transported, or if it is, there is a part that we are not able to treat or solve, it reduces in 80 to 90% the volume of residue that is being transported (...) So, we deliver the solution, environmentally (...), and socially we deliver a lot, because from the moment that you reduce the impact of your activity, you are delivering, to society, a reduction in emissions and other things, and still you are delivering employability to society, and the generation of income for the people that will be hired within this process. (E1)

Thus, treating MW internally, the solution proposed by the entrepreneur brings benefits such as reduction in hospital expenses, reduction of environmental impacts, due to the residue recycling and energy use processes, in addition to social gains through employability originating from these processes. In the hub format, the startup employs 12 people, and, in the two clients, 10 more people total. It is also worth emphasizing the preoccupation of the entrepreneur in promoting social inclusion in his projects when mentioning a successful experience in inserting a worker in a situation of social vulnerability, proposed by the Moinhos de Vento Hospital.

For the operation of the processes, the startup develops several machines and technologies in partnership with machine designers and fitters, engineering teams (electrical, mechanical, chemical, environmental) and software developers. In relation to contaminated residue, plastic and glass, the developed crushers are essential to reduce the volume of materials. In the contaminated residue treatment, autoclaves were developed to operate in reduced spaces, and, in this moment, a machine is being developed for treatment through microwaves, which would reduce the energetic consumption of this operation.

About the organics, it was incorporated a fast composting technology from a third party, the composts being studied to be certified through a partnership with the Agricultural, Livestock and Rural Development Department in the state of RS. The results of this study indicate the best options for the use of this material, which can be used in the gardens of the hospitals or in the crops of local farmers. A practical example of this occurs in the Moinho de Vento Hospital, which already uses this technology in their gardens.

The plastics, papers and glass are sent to the industry as raw material, being collected by a partner hired for this service. While the recyclables, unable to be used by close industries, are sent to a cooperative of recyclable material collectors of Porto Alegre. In the case of papers, the industry processes this input, transforming it in product, such as, toilet paper, which returns to the hospitals. According to the consulted documents, made available by the entrepreneur, the results are very encouraging: from 2014 to 2018, the recycling of the paper groups reached 863 tons, representing a saving of R\$316,946.00 in toilet paper in the Moinhos de Vento Hospital.

In the process of decontamination of biological waste and unserviceable plastics for their

transformation in energy cells, the decontaminated waste is crushed, and the polymeric rejects go through a synthesizing process to create energy cells. Currently, a multidisciplinary engineering team is developing the machine needed for the gasification of the energy cell. The result of the development of this process can be very advantageous for the clients, due to the high energy costs in generating vapor. Today, in the Santa Casa de Misericórdia Hospital of Porto Alegre, they use wood, because of the lower cost in comparison with natural gas, despite needing a larger storage area. On the other hand, in the Moinhos de Vento Hospital, they use natural gas. One of the benefits of the energy cell, besides cost, is the significant reduction in storage volume, which makes its handling and storage in small spaces easier.

Another solution developed for management is the management and control software through the application “Boomerang Method”. According to the entrepreneur, waste data control in the traditional methodology is usually very precarious, with no clear data regarding the internal operation indicators. While through the application, it is possible to create a digital data system, identifying the amount of collections performed per day, who are the operators, the duration, what are the non-conformities, what are the sectors, what are the plans of action, what are the trainings, etc. Lastly, the entrepreneur takes responsibility along with his clients, giving support and updates of the “Boomerang Method”, and certifying the companies that participate in the waste flow of the proposed managing system.

The proposed innovation in the “Boomerang Method” can be framed in the stage called by the Krüger, Araújo & Curi (2017) as “Green Investment” (involves greater financial/resource investment, extensive training and advanced equipment) and more elaborate strategies (upstream environmental, supplier development for environmental products, change of procedures). Traditional technology, on the other hand, is at the beginning of the hierarchy proposed by Krüger, Araújo & Curi (2017), with the first priority being the correct handling of waste, followed by waste reduction and then efficiency in the use of resources. In the model proposed by Krüger, Araújo & Curi (2017), the higher levels of the hierarchy reached allow for better levels of environmental performance for hospitals. However, at the higher levels there are some concerns for hospitals (expensive, long payback, uncertain payback, necessary training, new habits, specialized resources and workforce, data intensive), as opposed to the lower level which presents a comfortable situation in a conservative position (cheap, fast, fore-seeable outcome, “plug and play”, no training, no special resources or workforce, no data) (Krüger, Araújo & Curi, 2017).

With all of this MW managing system, one of the frequent words in Figure 1 was “Sustainability”. For the entrepreneur, the innovation suggested to the hospital sector allows to deliver value to the client, in such a way that sustainability is not restricted only to the environmental aspect in the solution proposed to the hospital. According to the entrepreneur, “(...) the premise is sustainability, I understand that you are also noticing that it is not an environmental sustainability alone, sustainability implies several issues”.

Furthermore, the entrepreneur mentions the UN’s SDO as an extension of the meaning of sustainability, traditionally based on the economic, social and environmental dimensions. According to the entrepreneur, the proposed solution should contribute to Sustainable Development, thus offering significant improvement in the hospitals’ operational performance. Therefore, in the data analysis, it is noted an alignment of his solutions with the concept of sustainable innovation, proposed by Barbieri *et al.* (2010), introducing products, productive processes, management methods that are new to the organization and that bring economic, social and environmental benefits, compared with existing alternatives, and a sustainable solution, proposed by Ottosson *et al.* (2017), because it is a solution designed to be a long-lasting, environmentally responsible solution for the



provider (the business), the society and the users. Furthermore, it can be seen as an innovation process, as discussed by Ottosson *et al.* (2017), because contains all stages from idea generation, development (R&D) and commercialization to an implemented solution on the market, with two notable hospitals in Porto Alegre using his innovation.

Although the traditional methodology also complies with the pertinent legislation, the “Boomerang Method” better complies with the NPSR principles, such as the “Sustainable Development” principle, and achieves better environmental performance as it reaches higher hierarchical levels of MW management in hospitals, as discussed in the model by Krüger, Araújo & Curi (2017).

4.3 SUSTAINABLE LEADERSHIP

In this subsection, perceptions of sustainable leadership in the context of sustainable medical waste management are discussed. In the discussion about sustainable leadership and its relationship with sustainable innovation, the words “Directors” and “Difficulties”, originated from the word cloud (Figure 3), were significant for understanding the issue. According to the entrepreneur, there are three levels that motivate the manager towards sustainability:

(...) The first level is the most basic, it is the law. It's a law, they have to do it, period. (...) I have to comply with the legislation, (...) the Conama (...), they will do everything to comply. On a level (...) above, we could put what is required, but not mandatory, like (...) an ISO. A company is not obliged to do it, but the market starts to demand it (...) then they start to think about implement an ISO, make norms, make gas inventory, and, thus, they seek to advance. And, on a third level, is what I call volunteering. Volunteering is like this: they already comply with the legislation, they are already doing an ISO, that is, (...) they already noticed their management maturity in the environmental field, they already noticed that they need to do some things and now they, 'no, wait, the responsibility is mine, I want to do this, I want to solve it, I want to be in front, I want to be a leader in the environmental field, I want to be, I want to show the world what I do'. So, (...) the company that is in this third level (...) will be leader (...) in the environmental field. Those professionals that are only thinking about complying with the legislation, or maybe implementing norms, those are going to be average (...). And on the third level, (...) you do thing outside the ordinary, you are not only going to recycle, you will recycle, you will involve a community (...). So, those that are on that third level will try do to different things and then you will be able to see better leaders, leaders proposing concrete solutions, solutions that last. (E1)

On the way to the third level, the entrepreneur reports cultural difficulties in changing the understanding of the hospital sector, in a way to take responsibility for developing the solution in their own establishments. In this direction, convincing the hospitals' upper management of the economic viability for approving investments is fundamental. In addition, the hospitals also started to note the importance of positive environmental and social results, starting to incorporate such actions in their marketing strategies, and strategies to capture bank financing with a sustainable line of credit.

However, the path is not easy, because the cultural aspect is the main limiter for adopting the solution in the hospital itself, the significant financial savings being the direct motivation for adopting the innovation. Later, the positive social and environmental results of the project are also visualized. In the case of hospital activity, according to the entrepreneur, the directors still do not focus on sustainability issues in their guiding business principles.

In fact, consulting the hospitals' institutional documents, no sustainability policies were identified, much less mentions in their organizational values. In the Moinhos de Vento Hospital, there is a great preoccupation in relation to the hospital having a quality service, through the implementation of ISO 9001. While in the Santa Casa de Misericórdia Hospital of Porto Alegre, their social



responsibility program is highlighted. According to the entrepreneur, these hospitals already had, in their organizational culture, an openness to accept sustainable innovation, walking towards the third level, mentioned previously.

The results found are in line with the model proposed by Krüger, Araújo & Curi (2017), which show the regulatory motivator as the first performance baseline, and the competitive motivator as the second baseline. The ethical motivator, on the other hand, has a lower weight in discussions for sustainable waste management. To overcome the difficulties, the entrepreneur seeks to sensitize the environmental managers and hospital directors, give lectures and participate in academic events, overcome regulatory obstacles, highlighting the viability and the gains of sustainability achieved with his innovation proposal. Regarding the engineering teams responsible for the environmental management in bigger hospitals, there is still not a wider perspective from sustainability to deal with the MW issue. Many times, the board of directors of medium and large hospitals considers the traditional method more convenient, because of the responsibility transference in taking the risk of treating MW internally. Thus, it is much easier to assume a position of only complying with the basic legislation and untangle from the residue. In this situation, the role of the entrepreneur, through his sustainable innovation, is to convince his clients to continue towards the third level. According to the entrepreneur, despite this path being hard, companies that are able to implement solutions aligned with SDO are in a different level of management and leadership.

In this context, it is perceived, in the startup, a search for leadership in sustainability, contemplating the guidelines for leaders in sustainability in the UN's Global Pact, and in line with the synthesis presented by Hallinger & Suriyankietkaew (2018) for the definition of "Sustainable Innovation", contemplating emphasis on leadership, rather than a unitary leader; long-term vision; broader goals that link organizations to society; ethical behavior; social responsibilities of leaders and organizations; innovation capacity; systemic change; stakeholder engagement; and capacity building of stakeholders. Through his proposal of sustainable innovation, the entrepreneur helps his clients to transform their organizational culture towards sustainability, from new attitudes, behaviors and responsibilities. Furthermore, according to Armaud and Sekerka (2009), the discussion around sustainable innovation should take into account the change in values, and not only the importance of the institutionalization of sustainable development, as in the sustainable innovation discussion in Barbieri *et al.* (2010). As seen in the case study, hospitals seek to reach only the first level, complying with basic legal requirements in relation to MW. To move towards sustainability, it is necessary to motivate hospitals to change their values, attitudes and practices, comprehending the gains from sustainable innovation in all dimensions, aligned with the SDO premises.

Lastly, the possibility of accelerating the startup through a partnership with the Moinhos de Vento Hospital can be a key element for the expansion of sustainable innovation in other hospitals in the country, overcoming cultural difficulties in relation to MW management. Through a better communication among the hospitals' boards, the successful experience of the Moinhos de Vento Hospital can be replicated with new clients, contributing to the Sustainable Development in other Brazilian cities.

5 FINAL CONSIDERATIONS

This research had the main objective of comprehending the innovations for MW treatment in the hospital sector, under the perspective of sustainable development, using the qualitative case study as research strategy. It was chosen an entrepreneur who develops avant-garde MW managing technologies and services in two large hospitals in Porto Alegre/RS, defining three specific



objectives to be investigated.

Regarding the MW management innovations proposed by the entrepreneur, it was verified the compatibility of his MW managing solution with the sustainable innovation concept, presented by Barbieri *et al.* (2010); and sustainable solution, presented by Ottosson *et al.* (2017). It is noted the alignment of his innovation with UN's SDO, maximizing the sustainability gains for the hospitals in the economic, social and environmental dimensions. It is also highlighted the better alignment of the "Boomerang Method" with the NPSR principles, in comparison with the traditional method, and in a higher hierarchical position in the model of Krüger, Araújo & Curi (2017) of Medical Waste management, with a better environmental performance for hospitals.

Regarding sustainable leadership characteristics, the entrepreneur showed to contemplate the UN's Global Pact guidelines and the definition of sustainable leadership, according to Hallinger & Suriyankietkaew (2018), for leaders in sustainability in his sustainable innovation proposal, helping his clients to transform their organizational culture, towards sustainability, from new attitudes, behaviors and responsibilities. In this case, the acceptance of his innovation proposals goes through a cultural change in relation to the conventional MW treatment, since the hospitals seek to reach only the first level, complying with basic legal requirements regarding MW. To move towards sustainability, it is necessary to motivate hospitals to change their values, attitudes and practices, comprehending the gains from sustainable innovation in all dimensions, aligned with the SDO premises.

As research limitations, it was not possible to visit the hospitals, due to the pandemic caused by coronavirus (COVID-19), making it impossible to see the MW management in loco, much less interview operators and environmental managers. It is recommended, for future research, to investigate the MW management data of the "Boomerang Method", quantifying the sustainability gains due to its implementation, as well as comparing with the traditional methodology, through new theoretical constructs.

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3. Development of theoretical propositions (theoretical work)			
4. Theoretical foundation / Literature review	√	√	
5. Definition of methodological procedures	√	√	√
6. Data collection	√	√	√
7. Statistical analysis			
8. Analysis and interpretation of data	√	√	
9. Critical revision of the manuscript	√	√	√
10. Manuscript writing	√		

