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APPLICABILITY OF SUSTAINABLE PRACTICES TO HEALTHCARE BUILDINGS

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INTRODUCTION

Construction is the least sustainable industry (Edwards, 2004) and the one that consumes the most natural resources, where, together with the use and maintenance of buildings, it consumes approximately 50% of the energy generated worldwide (GAUZIN, 2002).

Within the construction industry, health-care facilities (HCF) stand out for their extensive and in-depth planning, and are governed by regulations, restrictions and processes that make the life cycle of the building in which they are installed complex. HAEs are major impact generators and must prioritize the need for architectural design from the earliest stages of the project (KARMANN, 2011).

When it comes to sustainability, Sampaio (2005) states that it is related to environmental, economic and social aspects, and is currently a worldwide concern, and thus the application of sustainable practices, according to the Ministry of Health (BRASIL, 2015), can result in savings in financial resources and improvements in the provision of services to the population.

In order to value design practices that seek to reduce the impact caused by civil construction, qualification and certification seals have emerged, acting by identifying weaknesses both in the architectural design phase and in execution, verifying the sustainable practices applied that promise to reduce resource consumption in all phases of a building. The most widely used environmental certification system in Brazil is *Leadership in Energy and Environment Design* (LEED) (LEITE, 2011).

EAS consume a large amount of natural resources, where energy inefficiency and waste are usually recurrent, and occur both during the construction phase and during the post-occupancy period, due to the lack of control of operational and administrative management (GRIMM, 2012; BITENCOURT, 2006).

Within this context, this research aims to identify the possibilities of implementing sustainable practices in buildings used for EAS, to help develop better service conditions, providing users with environmental comfort, as well as seeking to reduce the consumption of natural resources.

OBJECTIVES

- Compile information on sustainability applied to Healthcare Establishments;
- Briefly analyze the case of a hospital located in Brazil that has been awarded LEED certification;
- Analyze and compile the certification criteria and strategies that can be applied to EAS buildings;
- To compile information on environmental comfort practices that help with building sustainability;
- Relate the requirements for LEED BD+C: *Healthcare* certification to ANVISA recommendations.

SUSTAINABILITY IN THE CONSTRUCTION SECTOR

DEVELOPING THE CONCEPT OF SUSTAINABILITY

Sustainable development has emerged as a philosophy that proposes a social evolution towards a more egalitarian world, in which the environment has become essential for the survival of future generations (WONG and ZHOU (2015). Accelerated population growth, among other things, has caused irreversible damage to the planet and its inhabitants, and has been a constant concern of governments in recent times (GAUZIN, 2002).

Sustainability is seen as the need to preserve the environment, as well as its economic and social implications, the pursuit of which has led industry to review concepts in order to compete with products that are more efficient in energy consumption and generate fewer pollutants (BRASIL, 2015).

According to the document entitled *The Limits to Growth*, published at a conference held in Stockholm in 1972, "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (BITENCOURT, 2006; LUGINAAH, 2005).

According to the United Nations (ONU-BR, 2017), the world is at a time of great challenges for sustainable development, and with the aim of achieving sustainable development in the economic, social and environmental dimensions, in 2015 the organization drew up and implemented the 2030 Agenda, with 17 sustainable development goals (Figure 1) and 169 targets to be implemented by the year 2030.

Among the goals presented by the 2030 Agenda, goal number *11* stands out - *Make cities and human settlements inclusive, safe, resilient and sustainable,* as it points out that "half of humanity currently lives in cities. By 2030, almost 60% of the world's population will live in urban areas".

SUSTAINABILITY IN THE BUILT ENVIRONMENT

According to Edwards (2004), the construction industry can be considered the least sustainable activity on the planet, as it uses up to 50% of the world's resources in materials, 5% of which are used for construction, and the rest for lighting, ventilation and heating buildings. The author points out that 40% of the water used worldwide is used to supply sanitary facilities, among other uses in buildings.

Gauzin (2002) states that construction and the use of buildings have a major impact on the environment, as they are responsible for using almost 50% of the world's energy and for the same percentage of carbon dioxide (CO_2) emissions. Lucas (2011) states that the increase in the world's population will result in an increase in the consumption of resources (Figure 2), since more housing will be needed to meet the needs caused by this growth.

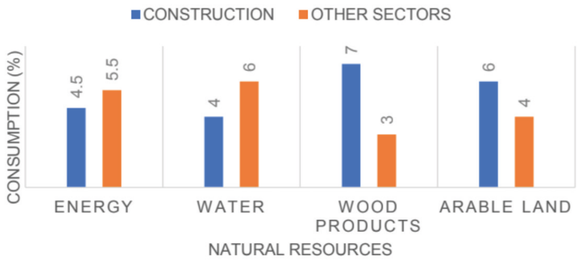

Figure 2 - Consumption of natural resources worldwide by the construction industry

Source: Adapted from Lucas, 2011.

Sustainable construction, according to Plessis (2007), can be achieved when the concept of sustainable development is inserted into all phases of the construction life cycle, becoming the result of a multidisciplinary process, with the intention of restoring and maintaining the balance between the natural environment and the built environment.

In order to approach a new construction process, its advantages must be verified by evaluating the level of performance that this process introduces into building construction (LUCAS, 2011).

In order to mitigate the negative environmental impacts and enhance the positive impacts of different types of projects, environmental assessment emerged in the 1980s as a mechanism for measuring these impacts. From the 1990s onwards, the issue of sustainability became a significant segment in the construction industry, characterizing the Green Building mode of construction. (LUCAS, 2011; PINHEIRO, 2006; USEPA, 2014).

Figure 1 - Goals of the 2030 Agenda
Source: ONUBR, 2017.

Sustainability in healthcare buildings around the world

Cities can and should be an open field for sustainable guidelines since the complexity of their scale ends up causing positive or negative impacts on the environment, as much as their own dimensions (CASTRO, MATEUS AND BRAGANÇA, 2012). As such, one of the objectives of the construction industry is to build a product that meets both the requirements of functionality and durability, while being safe and profitable during its life cycle.

Castro, Mateus and Bragança (2012) point out that these principles are leading to the elaboration of a concept of sustainable construction with different criteria, based on various scientific fields, thus emerging a greater concern with the humanization of the hospital environment where questions arise about the characterization of a sustainable hospital and what are the best practices for the elaboration of this type of building.

According to Kwok (2013), the definition of a green building is one that meets the minimum requirements demanded by certifications, while sustainable buildings and those considered high performance go beyond these requirements, seeking a more complete performance, including operations and building maintenance.

Yudelson (2013) points out that sustainable buildings use design and construction practices that significantly reduce, or even eliminate, the impact caused by buildings on the environment and, consequently, on their users.

Karliner and Guenther (2011), through the Global Agenda for Green and Healthy Hospitals (AGHVS), emphasize that the impact caused by hospitals on the environment is great, but not surprising, given the strength of the health sector in the economy, since in 2007 alone, between 8% and 10% of the global Gross Domestic Product (GDP) was used in health-related spending.

Countries like the United States and China are listed by AGHVS, as the former has its health sector as the main user of chemical substances, many of which have known carcinogenic effects. For its part, the Asian country's health sector spends more than 10 billion dollars a year on construction, a figure that is growing by 20% every year, one of the footprints of which is the high consumption of natural resources.

Of course, the various implications for environmental health exist in all shapes and sizes, and for only a few years the health sector has been trying to understand the impact that environmental problems could have on its services. Thus, according to the AGHVS, initiatives and conferences have been springing up in countries of all kinds to promote environmental performance in the health sector.

Sustainability in healthcare buildings in Brazil

The concept of environmental preservation based on the untouchability of natural resources has been overtaken by the concept of preservation in a new model, adapted to the rational use of available natural resources, so that they continue to be present in order to serve future generations (BRASIL, 2000).

Sampaio (2005) states that the idea of sustainability is related to environmental, social and economic aspects, where there is a search for a balance between economical growth combined with social justice and environmental preservation.

With regard to EAS, Grimm (2012) states that they currently fall into the group of large energy consumers, due to the numerous changes that have taken place during the 20th century.

Energy inefficiency and waste are common occurrences in hospital institutions, and can be caused by uncontrolled operational and administrative management or even by functional characteristics that require backup systems, which must be available at all times, especially in places where medical and hospital care may be provided (BITENCOURT, 2006).

According to data from PROCEL (2006), only 13.2% of hospitals have some form of energy management, and it is estimated that a potential reduction in consumption could be achieved through the implementation of energy efficiency measures, potentially saving up to 20% of electricity in public buildings.

In 2007, the Green Building Council Brazil (GBCBrasil) was created with the aim of being a reference for the evaluation and certification of sustainable buildings in Brazil using the LEED tool. According to Lucas (2011), it is one of the most widely used certifications in the country.

According to Bitencourt (2006), the sustainable hospital is a concept that needs to be consolidated and gradually incorporated into rules, laws and regulations. Sustainable development bases will also be developed and inserted for different building materials and working methods, as well as the equipment used in construction.

EAS are considered to be complex companies, since they house different sectors, each with its own functions and specialties. As such, they are large construction investment ventures, generating considerable expenses in the purchase of materials and equipment, as well as in the maintenance of operations (MARTINS, 2004).

According to the Ministry of Health (BRASIL, 2015), an architectural project based on sustainable principles will result in a building that meets the needs of its users, and should allow the building to interact efficiently with the environment, including energy savings and the environmental quality of the spaces designed. The project must achieve environmental comfort, taking into account the reality of the local climate from the initial planning of the building.

There are different strategies for achieving sustainability, including bioclimatic strategies such as LEED. The search for a sustainable building must be present in EAS projects, in order to help build a new paradigm of buildings that cause less environmental damage (BRASIL, 2015).

To exemplify the application of sustainable principles in Brazilian buildings, the following sections show a consolidated hospital in the city of São Paulo, with buildings awarded LEED certification.

Hospital Israelita Albert Einstein - São Paulo / SP

The Hospital Israelita Albert Einstein (HIAE) obtained LEED Gold Certification for the Vicky and Joseph Safra Pavilion (Figure 3) in 2010. Located in the city of São Paulo, the project designed by Kahn do Brasil covers an area of approximately 70,300 m².

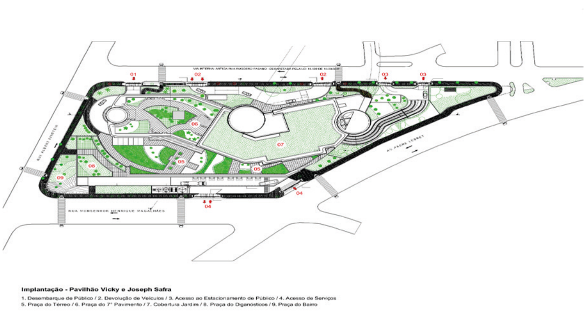

Figure 3- Implementation of the Vicky and Joseph Safra Pavilion - HIAE

Source: NUPEHA, 2018.

According to Castilho (2013), the success of the proposals implemented in the building was made possible mainly by the institution's initiative from the outset of the project's conception, one of whose priorities was to comply with the sustainable agenda, as well as a project in which there would be no major changes to the cost of the work, and which would be low-cost in terms of operation and maintenance.

As far as sustainability is concerned, the building (Figure 4) has kept its old pilotis configuration, where the main entrance has a square open to the community, with slabs covered with green roofs. This intervention was fundamental in reducing load gain through direct insolation on hotter days, as well as making it possible to reduce load loss on cold days, thus helping the building's energy efficiency.

Figure 4 - Vicky and Joseph Safra Pavilion - HIAE

Source: NUPEHA, 2018.

The almost 4,000 m² of rooftop gardens (Figure 5) at also play a role in water management, since it is through these open spaces that rainwater is collected and sent to specific reservoirs and, after filtering, is used for drip irrigation, which is 100% carried out with the water collected. As well as being used for irrigation, the water collected is also used for washing floors, in the air conditioning system and for the fire-fighting reserve. With the practices implemented, the pavilion has achieved savings of approximately 30% in water consumption.

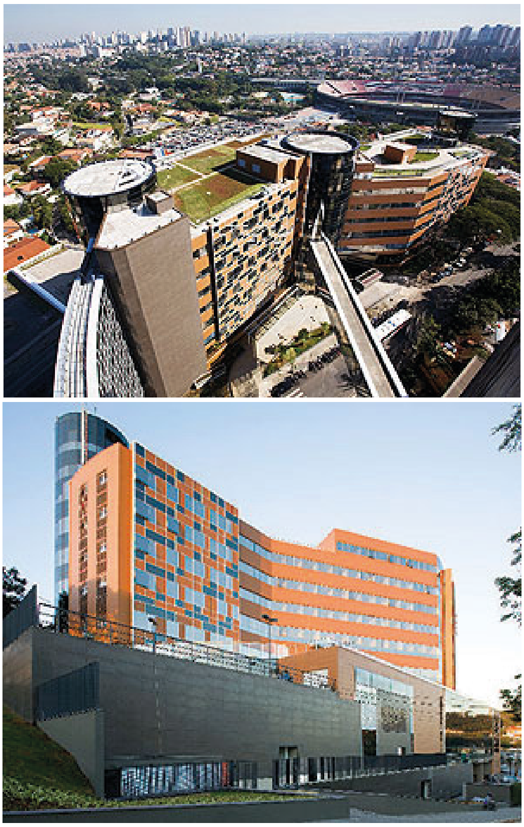

Figure 5 - Gardens on the roof of the Vicky and Joseph Safra Pavilion - HIAE

Source: NUPEHA, 2018; Revista Téchne, 2018.

The ventilated façade made of ceramic tiles (Figure 5) reduces the thermal load gain inside the building, and has frames made up of insulated double glazing fitted with internal micro-slats, thus reducing energy consumption.

Some points were crucial to the positive impact caused by the building, including the reduction in water and energy consumption, respect for the building's surroundings, the high quality and control of indoor air and the reduction of the heat island effect in the region.

With regard to energy, the east-west orientation of the building was planned in order to reduce the direct sunlight entering its openings, thus minimizing the gain in thermal load and, consequently, the energy demand from the use of air conditioning.

Waste management is also a constant concern at Albert Einstein Hospital. The institution has waste reduction and recycling programs, and has invested in equipment to sterilize infectious waste and compost organic waste, generating social, environmental and economic benefits.

The positive impact generated by the Vicky and Joseph Safra Pavilion, which is already certified, is of great importance. As well as this building, the hospital as a whole also has certification for the Perdizes Unit, and already has three other projects that are candidates for certification.

With the certification achieved in the LEED BD+C: Novav2 Construction - LEED 2.2 category, the development achieved 40 of the 69 possible criteria, the score of which is shown in Figure 6.

LEED POINTS CARD	40/69
Sustainable use of terrain	12/14
Water use efficiency	03/05
Energy and atmosphere	04/17
Materials and resources	06/13
Internal Environmental Qualit	10/15
Innovation	05/05

Figure 6- LEED scorecard - Vicky and Joseph Safra Pavilion - HIAE

Source: Adapted from USGBC, 2010.

STANDARDIZATION, ACCREDITATION AND SUSTAINABILITY IN EAS

This chapter presents some criteria for designing and maintaining an EAS, since this type of establishment is governed by specific rules for its operation. Regulations, accreditations and manuals are widely disseminated by the Ministry of Health (MoH) and the National Health Surveillance Agency (ANVISA) in order to reach managers, designers and users of healthcare buildings, whose planning, occupation and maintenance obtains extensive benefits for its users, as well as for the locality in which it is located.

Standardization in EAS

ANVISA was created in 1999 with the aim of regulating and supervising all activities linked to public health, which includes the standardization for the elaboration of architectural projects for EAS, whose first standards appeared in the 1970s (LIMEIRA, 2006).

Barcellos (2012) points out that the model in force when the first regulations were created had a direct influence on the guidelines adopted by this document, using predetermined typologies, predefined architectural programs and nationwide parameters based solely on demographic data.

The standards and guidelines related to the physical infrastructure of EAS are currently developed by the General Management of Technology in Health Services (GGTES). These aim to rationalize the use of spaces and provide uniform information on the feasibility of architectural projects for healthcare buildings, to in order to improve the quality of their services (ZAMPIVA, 2016).

After the creation of the Unified Health System (SUS), the strategy adopted for health care in Brazil was changed through a new proposal for a care model based on comprehensive health surveillance, through planning and the participation of health professionals and users of the system, based on epidemiological data in order to set up a quality care network (BARCELLOS, 2012).

As a result of the implementation of this new model, MS drew up various documents, the evolution of which culminated in MS Ordinance No. 1889 of 1994, which aims to establish Standards for the Physical Design of Healthcare Establishments, having been updated in 2002 by Anvisa Collegiate Board Resolution No. 50 (RDC 50).

According to Bitencourt and Costeira (2014), among the normative documents published by ANVISA are those listed the creation of the National Humanization Policy (PNH) in 2003 and the National Patient Safety Program (PNSP) in 2013.

The main Brazilian standard that regulates architectural projects in the healthcare area is RDC 50, which suggests a methodology for preparing HCS projects by defining attributions, functional program, activities, minimum dimensions and criteria related to comfort. Divided into three parts, RDC 50 (Chart 2) deals with the Physical-Functional Programming of Healthcare Facilities in the first chapter (ZAMPIVA, 2016).

According to Zampiva (2016), the second chapter deals with the Physical-Functional Programming of the EAS, providing definitions of the functional organization, activities, sizing, building installations and quantification of the environments. It presents tables listing the characteristics that must be adhered to in order to correctly prepare the EAS.

The third and final part involves the Design Criteria for EAS, encompassing variables that help with the decision-making that takes place during the different stages of developing an architectural project. Zampiva (2016) explains that this chapter provides information on circulation, environmental conditions for comfort and infection control, firefighting facilities to and special and ordinary facilities.

 https://doi.org/10.22533/at.ed.2164202420098

FUNCTIONAL UNIT:3 - ADMISSION

Activity N.	UNIT / AMBIENT	QUANTITY (min)
3.1	*General Admission (newborn, children, adolescent, adult)*	
3.1.2;3.1.3	Nursing station / medical prescription	1 for each 30 beds
3.1.3	Service room	1 for each station
3.1.2;3.1.3	Examination room and dressings	1 for each 30 beds
3.1.2	Medical prescription area	
3.1.3	Infant care and hygiene area	1 for each 12 beds or fraction
3.1.1 to 3.1.5;3.1.7	Infant ward	15% of the beds Minimum 1 room for isolation for each 30 beds or fraction
3.1.1 to 3.1.5;3.1.7 4.5.9	Children room	
3.1.1 to 3.1.5;3.1.7	Children ward	

Table 2- Table of requirements for EAS

Source: ANVISA, 2002.

In addition, there are also other rules and regulations linked to healthcare establishments, such as Municipal Legislation, Fire Department resolutions, Brazilian Standard (NBR) 9050 - ABNT, RDC 306 (Waste Management), the Ministry of Labor's NR 32, among other resolutions, good healthcare practices and published ordinances.

EAS accreditation

Hospital accreditation is a certification aimed exclusively at healthcare establishments and is generally a voluntary process. The accreditation process has a formal protocol through which a qualified body assesses and recognizes whether the institution under analysis complies with pre-established published quality standards (LIMA, 2010; ZAMPIVA, 2016).

Different organizations may complement RDC 50 with accreditation manuals, such as the *Joint Commission on Accreditation of Healthcare Organizations* (JCAHO), which is an international organization, or even the National Accreditation Organization (ONA), a Brazilian body. According to Guelli (2010), these organizations already include the perception of physical space by users, patients or service providers as an indispensable variable.

The Ministry of Health, through the Brazilian Hospital Accreditation Manual (BRASIL, 2002), establishes that every hospital should be concerned with the continuous development of the quality of its management and care, aiming to integrate the medical, technological, administrative, economic, care and teaching and research areas, when necessary.

Lima (2010) mentions that accreditation standards are based on the best performance already achieved by the institution, and are designed to stimulate efforts to permanently improve quality in other accredited institutions.

However, despite accreditation, Guelli (2010) points out that this type of certification does not include in its assessment criteria linked to space, such as functionality, flexibility, expandability and adaptability, leaving a gap in the complete assessment of hospital buildings.

Principles of sustainability in EAS by the Ministry of Health

In 2010 and 2011, through evaluations and discussions of EAS projects analyzed, the Ministry of Health formulated a set of principles that should be adopted for the qualification of federal investments in physical health structures in Brazil.

According to the manual Qualification and Sustainability of Healthcare Establishment Buildings (BRASIL, 2015), the sustainable assessment of healthcare buildings should begin with environmental impact studies of the work, which could make it inadvisable to carry it out. The action encompasses a set of environmental changes that can result from a construction project.

The evaluation carried out by the MS covers productivity, performance, efficiency, performance, cost/benefit ratio, investment/ cost, and the relationship between this environment and its users. The aim of the assessment process was to find out about the characteristics and particularities of the implementation of the project, and from the information obtained it became possible to plan possible changes to the technical, economic and regional characteristics of a given project.

The information collected to evaluate the projects was aimed at the following points:

- Help with understanding the planning, what is being proposed and the material to be used;
- Knowing the environment in which the work will be carried out and predicting possible environmental impacts caused by the action and quantifying the expected changes;
- Disseminate the results for use in the decision-making process;
- EAS projects must comply with RDC 50;
- Projects must comply with NBR 9050 ABNT (Accessibility to buildings, furniture, spaces and urban equipment);
- There must be a basic program of needs for the project, containing all the environments necessary for the development of the activities to be carried out.

Based on the evaluation of the aforementioned criteria, recommendations were drawn up for the design of architectural projects in order to improve the quality of the implementation of healthcare facilities, which can be found in the next chapter .

These recommendations were drawn up with the aim of achieving comfortable and qualified environments for the processes required in an EAS, as well as qualifying federal investments in EAS in Brazil.

SUSTAINABLE STRATEGIES AND TECHNOLOGIES FOR BUILDINGS

EAS qualification strategies

The Ministry of Health, through the manual Qualification and Sustainability of Healthcare Establishment Buildings (BRASIL, 2015), establishes recommendations for sustainable practices in order to help public healthcare establishments qualify their physical structures.

The strategies are interlinked different topics related to both the design and implementation stages of the project. The recommendations are set out in Table 3.

To complete the set of recommendations for sustainable practices that can be adopted in the planning and design of hospital buildings, the Ministry of Health's publication highlights the importance and influence of design innovation.

A complex building like an EAS has daily challenges, so its planning must include innovative, integrated and creative solutions in order to solve problems and overcome difficulties.

1. Project integration: interdisciplinary and integrated planning based on sustainability guidelines; **Suggested strategies:** widespread awareness of the benefits of sustainable design; use of computer tools to forecast consumption; sustainable design strategies;
2. Implementation: local ecological integrity must be recognized, strategies must be proposed to minimize impacts on the environment, and dependence on mechanical systems in buildings must be reduced; **Suggested strategies:** reuse and renovate existing buildings, orient the building to make better use of sunlight and natural ventilation, use native vegetation;
3. Water: water-efficient design and maximizing the use of local natural resources; **Suggested strategies:** specifying low-consumption metals with automated closing, collecting rainwater for reuse in irrigation, flushing or replacement, using permeable surfaces;
4. Energy: a good quality environment must be guaranteed, allowing the patient to recover well, while at the same time drawing up a plan for low energy consumption or reducing energy demand; **Suggested strategies:** adapting the layout of the building to make better use of solar orientation in order to optimize energy efficiency performance, using natural lighting, specifying efficient air conditioning units, using renewable energy systems with a low environmental impact;
5. Indoor air quality: eliminating materials identified as carcinogens or allergens, using appropriate temperatures, ventilation and air exchange; **Suggested strategies:** minimize the use of carpets and other pollutant-absorbing materials, specify certified products, systems and materials that attenuate noise and vibrations;
6. Materials and Products: use sustainable materials, aim to minimize the production of toxic and bioaccumulative substances; **Suggested strategies:** specify materials free of toxic chemicals that do not release toxins over their lifetime, avoid materials such as mercury and arsenic, give preference to recyclable, biodegradable or reusable materials, avoid waste by standardizing systems and structures;
7. Construction process: directly related to the project, it will have an impact on the health of the environment during construction and will determine whether the building will achieve its objectives in the long term; **Suggested strategies:** implement a waste management plan during the construction phases, reuse possible materials, store hazardous materials in secure warehouses;
8. Operation and maintenance: for the operation and maintenance phases of a hospital building, its impacts must be planned, and community involvement in actions to rationally consume materials and resources must be provided for, as well as combating waste; **Suggested strategies:** design suitable spaces to facilitate the processes of recycling and composting waste, places for the correct storage of contaminating waste, promote talks to raise awareness and publicize the benefits of the practices adopted, as well as preparing and disseminating manuals on the systems intrinsic to the building;

Chart 3- Recommendations and sustainable strategies recommended by the Ministry of Health.

Source: BRASIL, 2015.

CERTIFICATIONS AND SEALS	ORIGIN	YEAR
BREEAM (*Building Research Establishment Environmental Assessment Method)*	United Kingdom	1990
HQE (*Haule Qualité Environnementale des Bâtiments)*	France	1996
LEED (*Leadership in Energy & Environmental Design)*	USA	1998
EEWH (Assessment System)	Taiwan	1999
CASBEE (*Comprehensive Assessment System for Building Environmental Efficiency)*	Japan	2001
Geen Star	Australia	2002
HK-BEAM *(The Building Environmental Assessment Method)*	Hong Kong	2002
SBAT *(Sustainable Building Assessment Tool)*	South Africa	2005
LIDERA (Voluntary System for the Evaluation of Sustainable Construction)	Portugal	2005
DGNB *(German Sustainable Building Council)*	Germany	2007
AQUA (High Environmental Quality) - based on HQE	Brazil	2007
PROCEL EDIFICA (National Program for the Preservation of Electricity in Buildings)	Brazil	2009
Caixa Blue House Seal	Brazil	2010

Table 4- Environmental certification labels for sustainable buildings

Source: Adapted from Rómero and Reis (2012).

EAS sustainability certifications

From the 1970s onwards, the environmental issue gained prominence, and it was in the late 1980s that environmental assessments began to emerge and become established in order to identify the impacts resulting from the influence of human development. During this period, different government agencies established mechanisms to demonstrate continuous improvement by combining aspects of performance classification and certification systems (LEITE, 2011; PINHEIRO, 2006).

Over the years, constant environmental problems have led different branches of industry to intervene in the processes they develop (ZUTSHI; CREED, 2015). As Giama and Papadopoulos (2015) point out, the importance of change in reducing environmental impacts and controlling the waste and pollutants generated is clear.

In order to improve the performance of construction systems and buildings, different certification systems have been created, based on voluntary adherence to evaluation systems with pre-established parameters (LU; ZHU; CUI, 2012).

Among the various environmental assessment systems (Chart 4), LEED and AQUA are the most widely used in Brazil, the former being carried out by GBCBrasil and the latter by the Vandolini Foundation. Both processes are concerned with waste generation, the preservation of natural resources, interaction with the environment, among other criteria common to both certifications (LEITE, 2011).

Among the benefits acquired by companies that choose to adhere to environmental certification for their works are the appreciation of real estate, greater potential to reach new markets, reduced production costs and skilled labor, increased credibility and visibility in the eyes of the population. These advantages are positive, since environmental awareness has increased among consumers of buildings, and water and energy saving systems add value to the work and demonstrate awareness of the consumption of natural resources (LEITE, 2011; SEBRAE, 2016).

Leadership in Energy and Environmental Design - LEED

Developed in 1999 in the United States of America, LEED was considered a consensual performance rating system, with the aim of developing and implementing design and construction practices, exulting in financial and economic incentives for the sustainable construction market in Brazil, and is currently the best-known certification in the world (SOUSA, 2012; MOURA; MOTTA, 2013).

Developed by the USGBC, the evaluation system works on a voluntary basis and is applicable to any type of construction and phase of the project (ZAMPIVA, 2016). Its methodology is based on points, these being credits, which generate indexes, which are weighted by categories in four levels, which depend directly on the score obtained in the evaluation. These are Basic Certification (from 49 to 49 points), Silver Certification (from 50 to 59 points), Gold (from 60 to 79 points) and Platinum (from 80 points), as illustrated in figure 7.

Figure 7- LEED certification levels.

Source: GBCB, 2014.

In order to pass the LEED evaluation system, it is necessary to meet a number of performance criteria distributed in specific areas (Figure 8), which are subdivided into specific scoreable areas, where some criteria are mandatory (LEITE; GBGC, 2011).

Key Areas		Criteria
	Site Sustainability (SS)	Erosion and control of these mints are site selection and urban development and development of environmentally contaminated sites, transportation, reduction of construction disturbances, management of severe weather situations, restoration and protection of open spaces, landscape, exterior design and reduction of direct light radiation output.
	Water Efficiency (WE)	Water effiency usage, inovative treatment technology
	Energy and Atmosphere (EA)	Building systems fundamental instructions, minimum energy performance, CFC reduction, renewable energy, additional instructions, measurement and verification, green energy and ozone layer gradation.
	Materials and Resources (MR)	Collection and storage of recyclable materials, use of difficult construction waste management resource, use of recycled content of materials, local and regional materials, rapidly renewable materials and certified wood.
	Internal Environment Quality (IEQ)	Information about innovative measures incorporated into the building and what are the sustainable benefits
	Innovation and Project Development (ID)	Minimum indoor air quality performance, indoor tobacco smoke control, carbon dioxide monitoring, increasing ventilation efficiency, indoor air quality management plan, low VOC emission materials, ability to control thermal comfort systems.

Figure 8- Assessment areas for LEED approval.

Source: Leite, 2011.

LEED v4 for BD+C: Healthcare

Project Checklist

Project Name

Date

Y	?	N			
Y			Prereq 1	Integrative Project Planning and Design	Required
			Credit 1	Integrative Process	1
			Location and Transportation	**Possible Points:**	**9**
			Credit 1	LEED for Neighborhood Development Location	9
			Credit 2	Sensitive Land Protection	1
			Credit 3	High Priority Site	2
			Credit 4	Surrounding Density and Diverse Uses	1
			Credit 5	Access to Quality Transit	2
			Credit 6	Bicycle Facilities	1
			Credit 7	Reduced Parking Footprint	1
			Credit 8	Green Vehicles	1
			Sustainable Sites	**Possible Points:**	**9**
Y			Prereq 1	Construction Activity Pollution Prevention	Required
Y			Prereq 2	Environmental Site Assessment	Required

Figure 10 - Checklist for LEED assessment - v4 for BD+C: Healthcare.

Source: GBCB (2014).

LEED certification can be applied to different types of building, which are classified into different categories, as shown in figure 9. Each evaluation category has specific criteria and scores in order to better evaluate each required prerequisite.

CATEGORY	DESCRIPTION
LEED NC	New constructions and big retrofit projects
LEED ND	Neighborhood development (local)
LEED CS	Projects around and in the central part of the building
LEED Retail NC and CI	Retail store
LEED Healthcare	Health units
LEED EB-OM	Maintence operation in existing buildings
LEED Schools	Schools
LEED CI	Interior design and commercial buildings

Figure 9 - Categories by building type for LEED evaluation.

Source: Leite, 2011.

According to Zampiva (2016), among the building categories, LEED *Healthcare* encompasses the needs of a hospital, with specific goals and credits, such as air quality, acoustics and the materials used, as shown in the *checklist* in Figure 21.

Currently, Brazil already has its own *Green Building Council* representative, which contributes to an increase in the number of projects being evaluated for certification. It should be noted that categories for additional credits are available for innovation, design process and regionality (ZAMPIVA, 2016; GONÇALVES; KLAUS, 2015).

Environmental comfort strategies

In order to highlight good ideas for applying sustainable methods and techniques, ANVISA drew up a number of scores in 2014 and 2015 to help improve environments for users and staff during care and procedures carried out in healthcare environments.

These strategies can overcome a wide variety of difficulties encountered on the road to environmental certification, or even the impossibility of applying it in small institutions or public services, for example. Therefore, it was decided to dedicate this part of the work to an overview of strategies that can be applied to a wide variety of buildings.

According to the Qualification and Sustainability of Healthcare Establishment Buildings manual (2015) and Sampaio (2005), in order to make environments more welcoming, the design of a hospital environment must take into account the climate in which it is located, its surroundings, energy efficiency and the environment, always thinking about the quality of life and well-being of the user.

Considering a few topics, some of the strategies mentioned that can have a positive impact on an EAS project are intrinsic to the climate and location of the project site, local sunshine, protection against direct sunlight and cold winds, thermal insulation, energy efficiency, building and finishing materials and practices to reduce the consumption of natural resources and waste production.

Among the strategies cited by ANVISA (BRASIL, 2015) are:

- Taking care with solar and wind orientation can determine variations in the thermal loads of internal environments;
- Preference for airy terrain;
- Correct use of direct sunlight, with the use of solar protection on façades where necessary;
- Use materials with a low thermal conductivity index;
- Installation of efficient light bulbs and equipment;
- Use of recyclable and certified building and finishing materials;

- Roof with insulation suitable for the local climate;

- Use of renewable energy systems;

- Reusing rainwater and reducing consumption;

- Recycling dry waste and reducing waste production.

In 2014, ANVISA released a publication entitled Conforto Ambiental em Estabelecimentos Assistenciais em Saúde (Environmental Comfort in Healthcare Facilities), which proposes specific tactics for hygrothermal, acoustic, visual and ergonomic comfort.

In relation to thermal comfort tactics, the ANVISA manual (BRASIL, 2014) establishes environmental and personal factors as the main influencers, so air temperature, relative humidity, metabolic heat and clothing are some of the items that are subject to greater care.

When it comes to acoustic comfort tactics, Góes (2011) recommends moving away from places that produce excessive noise.

The use of landscaping solutions and a review of the acoustic impact of equipment are also pointed out, as is the use of certain materials for floor coverings, such as vinyl sheets or blankets, in order to reduce the reverberation of unwanted sounds.

To ensure the quality of the built environment in terms of visual comfort, the manual mentions controlling the use of light and its intensity, as well as planning a lighting project that directly influences glare, light directionality, color aspects and the use of natural light.

In order to adapt environments to ergonomic comfort standards, the publication suggests adapting the building in all the areas required by NBR 9050, which deals with accessibility to buildings, furniture, spaces and urban equipment for all people. With regard to olfactory comfort, care is recommended in choosing materials that do not produce odours during their useful life, and special emphasis should be placed on environments that produce specific odours, such as the Sterile Material Centre (SMC) and waste shelters, where it is necessary to install an efficient exhaust system in order to minimize their harmful potential.

In this way, exploring new construction methods, preserving the environment and reducing costs can aim to improve the quality of life of users of EAS, producing building/ environment interaction in an efficient and sustainable way .

LIST OF LEED BD+C: HEALTHCARE CERTIFICATION REQUIREMENTS AND ANVISA RECOMMENDATIONS

In the course of this work, it was possible to see that some of the requirements and credits in the LEED BD+C: *Healthcare* certification *checklist* are also present in the recommendations of ANVISA publications.

Authors such as Bitencourt and Costeira (2014) have already emphasized that humanization plays a strategic role in hospital buildings, acting directly on the design concept. It is the duty of all hospitals to have an architectural design that is compatible with their activities and friendly to their users.

According to the publication Qualificação e Sustentabilidade das Construções dos Estabelecimentos Assistenciais de Saúde (2015) and the manual Conforto Ambiental em Estabelecimentos Assistenciais em Saúde (2014), the application of sustainability practices in the hospital environment is recommended. The reuse of rainwater and the use of solar energy as a renewable energy source help to reduce costs.

The use of systems to manage water consumption and waste disposal are strategies aimed at reducing the damage caused to the environment. In addition, the use of green roofs and alternative coverings helps with the building's thermal comfort.

ANVISA publications have been produced since 2002, dealing with items directly related to LEED certification requirements, thus encouraging the implementation of sustainable strategies and paving the way for certification that is easier to obtain, as well as demonstrating a commitment to the environment and the future.

CONCLUSION

To conclude the work, the conclusions of the research will be analyzed in depth, and suggestions will be made for future work. In addition, this chapter will verify that the objectives of the work have been met.

This study analyzed different types of evaluation, certification and application of sustainability and environmental comfort strategies and practices. It was shown that the LEED certification system is the most widely used label today, and that the BD+C: *Healthcare* typology is suitable for verifying healthcare facilities.

At the end of this research, it was demonstrated that the study fulfilled its objective, since the work highlighted the existence and importance of certification criteria as well as recommendations for the qualification of healthcare environments and improvements in environmental comfort.

In addition, the research showed that the implementation of innovative technologies, such as the installation of photovoltaic panels and the use of low-toxicity materials, can be enough to transform an existing building into a comfortable and constructively sustainable environment.

It was also found that the requirements demanded by the certification are suggested by ANVISA as sustainable practices applicable to healthcare establishments, highlighting user comfort as the main purpose of possible changes, together with reducing building maintenance costs and energy consumption.

It is hoped that this research will reach hospital administrators and entrepreneurs throughout Brazil, who strive to certify the healthcare facilities in which they operate, in order to make them efficient, sustainable and comfortable for their users.

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