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City, Territory and Architecture

CASE STUDY

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Applying the benefits of biophilic theory to hospital design

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Abstract

Introduction: In 1839, the Lexicon Medicum mentioned the "healing powers of nature", arguing that many illnesses could be cured without the help of medicines, simply by paying attention to air, food, rest, physical activity, and state of mind. Therefore, already then, the environment was considered therapeutic and capable of affecting the health of individuals and helping their recovery (Hickman in Therapeutic landscape. A history of English hospital gardens since 1800, 2013). This awareness has remained valid since then, although the approach has changed and evolved over time.

Case description: In the 20th century, these assumptions have been supported, among others, by the research carried out by Ulrich on the ability of surgical patients to recover when they were exposed to the sight of nature. Indeed, there is a growing body of research which confirms the benefits of interacting with nature in hospital settings. The results of such studies have helped to better define a new approach to design that benefits the psychophysical well-being of individuals and improves their health (i.e. biophilic design).

Discussion and evaluation: The aim of this article is to highlight the growing importance of a cultural change in the design of spaces aimed at reconnecting individuals with the patterns and processes of nature, both in the urban context and, in particular, in healthcare spaces. This study intends to contribute to the ongoing debate concerning a new architectural language for hospitals and to shed light on the key features of health-inducing buildings.

Conclusions: The global health challenges of the 21st century require a new way of thinking and a change in the organisation of healthcare services through an approach that considers human needs in their entirety, and not in a strictly therapeutic sense. According to several studies, the humanisation of healthcare spaces and contact with nature can empower the patient and have a positive impact by reducing stress and pain and improving emotional wellbeing. However, further studies are required not just in order to deepen our understanding of the human-nature relationship and its impact on health, but also to change our approach regarding patients' health by considering a new vision of medicine, healthcare and healing environment.

Keywords: Biophilic design, Hospital, Nature, City

Background

Humanity evolves in close relation to nature and the quality of this relationship is reflected in the emotions, thought, culture, and health that every individual or society expresses. In modern times, however, the built space has been conceived and designed by giving nature a role that is not only marginal, but also irrelevant to the health and happiness of individuals (Kellert 2012). As early as the 1960s, in *Silent Spring*, Rachel Carson described the irreversible damage caused by the use of pesticides, foreseeing a scenario in which bees no longer danced on flowers, with no pollination nor fruits. Carson thereby started contemporary ecological thinking, and in the later *The sense of wonder* she argued: "What is the value of preserving and strengthening the sense of awe and wonder, the recognition of something beyond the boundaries of human experience? Is the exploration of the natural world just a pleasant way to pass the golden hours of

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childhood or is there something deeper? I am sure there is something deeper, something lasting and significant. Those who dwell […] among the beauties and mysteries of the earth are never alone or weary of life […] There is something infinitely healing in the repeated refrains of nature" (Carson 1998).

This does not mean demonising the modern lifestyle or thinking that it is necessary to distance ourselves from cities, from built environments or from technological advancement. However, it is certainly necessary for urban design to have a design quality oriented to the physical and emotional reconnection with nature, its patterns and its processes.

In other words, the compatibility of a building with the needs of the contemporary city is not limited to the design of the physical structure, but it also includes the functions and relationships that it produces and its ability to communicate with the surrounding environment with an exchange of value, in synergy with the individuals who enjoy it as a space dedicated to housing, work, leisure, but also healthcare.

In spite of their being very insightful, Kevin Lynch's and Jane Jacobs's studies on orientation and perception, and those by Christopher Alexander on natural forms applied to architecture, ultimately failed to give proper recognition within urban planning culture to the importance of people's emotional reactions to the built space. At the same time, the concept of environmental sustainability has been emptied of any meaning and has become one of the rhetoric expressions that permeate contemporary society.

As a matter of fact, the continuous erosion of the perceptual sphere of individuals through the standardisation of space has shown a resistance to change over time. The contemporary city—extensive and polycentric—gives the illusion of living in the green and in contact with nature but at the same time increases the ecological and environmental crisis of the territory. An urban space, in short, which is often described as the anti-city made of solitary buildings and land use (Totaforti 2017).

In contrast, the objective should be to pursue an urbanisation that is not in conflict with the natural environment, perhaps by adopting the best intuitions of well-established city planning on the one hand, and of *landscape urbanism* on the other. Such urbanisation expresses the characters of biophilic design, of *biomimicry* that sees nature as a "model, measure and mentor" (Benyus 1997), respecting the needs of individuals and contributing to building a liveable city, by promoting biodiversity and a greater connection with nature and with the other forms of life.

The very idea of biophilic design was actually born from the growing awareness that the mind and the human body develop within a "sensorially rich world" that is fundamental to people's health and intellectual, emotional and spiritual well-being. Humanity evolves through adaptive responses to natural conditions and natural stimuli, such as sunlight, plants, animals, water and landscapes. In fairness, the age of technology has facilitated the conviction that humans can ignore their association with nature and that progress can be measured with the ability to transform the natural world. This illusion has encouraged the environmental degradation and the separation of humankind from natural systems and processes (Kellert et al. 2008). The dominant paradigm has become a growing alienation of humans from nature and a growing loss of the meaning of places (Kellert 2012). Mumford (2007) was one of the first to argue that urban concentration produces an emptying of the natural environment and that covering more and more roads with pavement and tarmac modifies the perception of individuals.

According to Galimberti, the origin of this condition is to be found in the idea that nature can be considered as the human dwelling, in the adoption of an anthropocentric vision—not far from the Judeo-Christian notion that inspired modern science—in which nature is defined in relation to humankind. The ecological question arises from the increasingly exasperated conflict between the ways in which humans affect the environment, by modifying it, and their being subjects to laws of nature that are outside their control. While depending on the environment, humans detach themselves from it with their ability to create alternative models, more or less distant from the natural one and sometimes opposed to it. The city is nothing but the artificial world that humans needed to create in order to ensure their survival. According to Bateson, the ecological crisis has been caused exactly by technical progress, population growth and a misguided approach, typical of western thinking, to the human-nature relationship, which does not recognize that the creature that manages to win against its own environment eventually destroys itself, since it moves away from the structure to which it innately belongs (Scandurra 2001).

The modern city developed from an unshakeable faith in technology that determined a definitive opposition to nature and that assumed a future scenario, to which it tends, where progress would save the world and free it from evil and suffering. Today, we are aware that the categories of modernity are increasingly inadequate to describe the present or to hypothesise the future, but the gaze of humans is short-sighted and they cannot find a way to reconcile themselves with nature and the environment to which they belong.

By virtue of being a man-made artificial environment, the city expresses this opposition, this conflict. David Orr

describes this condition by pointing out that today "most [modern] buildings reflect no understanding of ecology or ecological processes. Most tell its users that knowing where they are is unimportant. Most tell its users that energy is cheap and abundant and can be squandered. Most are provisioned with materials and water and dispose of their waste in ways that tell its occupants that we are not part of the larger web of life. Most resonate with no part of our biology, evolutionary experience, or aesthetic sensibilities" (Kellert et al. 2008).

Recognising the importance of the need for change therefore means trying to minimise the impact that modern progress has on human health and the environment. Moreover, the broadest and most accredited definition of sustainability refers precisely to the integration of social, economic and environmental values. As John Elkington suggests, this is a multi-dimensional process that, however, has historically focused almost exclusively on the environmental aspect through, for instance, a design that is able to reduce the so-called "ecological footprint" of a building (Wackernagel and Rees 1996), and the economic aspect. This is evidenced by the extraordinary growth of the American *Green Building Council* (USGBC) with the rating that assesses the sustainability of buildings known as the LEED (*Leadership in Energy and Environmental Design*) and its widespread presence at the forefront of the debate on urban sustainability. This is certainly an important aspect, but it is absolutely inadequate to achieve the goal of urban sustainability and of the health and well-being of society. On the contrary, the social dimension of sustainability has often been neglected. Only recently, some programs such as the Living Building Challenge or the WELL Building Standard have recognised the importance of the human dimension of sustainability by defining goals for health, air quality and beauty. It is therefore clear that sustainability, as a social value, is an underestimated aspect in the city's design.

The main weakness of current sustainable design is therefore an approach overly focused on the "respect" of nature—which is therefore considered "other" than humankind—and on the ability to avoid harmful impacts of the built environment on the natural environment. In other words, the so-called ecological approach often translates into managerial technicalities, or what goes under the name of low environmental impact design. In spite of its importance, this view fails to meet the equally vital need of reducing the separation between humans and nature by improving the contact with processes related to the natural environment and building according to an approach that is culturally and ecologically geared towards human health and well-being.

True sustainability should therefore combine low environmental impact design with biophilic design (or positive environmental impact design) obtaining what is called restorative environmental design (Kellert et al. 2008). This is a paradigm aimed at reconstructing a harmonious relationship between humans and nature in the built environment. Within this framework, biophilic design arguably represents the missing element in sustainable design, which is still tied to an idea of nature understood more as an ethical value, than as a biologically given condition.

Biophilic design

Talking about the spread of biophilic design principles within the contemporary city's development needs a terminological premise. The term "biophilia" was used for the first time in the 1960s by Erich Fromm, to describe the tendency of humans to be attracted to everything that is alive and vital. According to Fromm's socio-ecological analysis, biophilia was the result of humans' non-disruptive relationship with the environment, based on the presence of three essential requirements: security, justice and freedom.

In 1980, the biologist Edward O. Wilson defined biophilia as "the inherent human inclination to affiliate with natural systems and processes, especially life and life-like features of the nonhuman environment" (Kellert et al. 2008). It is inherent because it does not come from experience, and it is emotional because it has the potential to influence aspects related to people's psychological sphere and emotional health. Biophilia therefore indicates both an evolutionist adaptive character (i.e. the ability of the strongest to adapt to the conditions of the surrounding environment that has been transmitted through a stereotyped system of symbols common to the entire human race) and an emotion. It is therefore an extremely complex concept that refers to the relationship that has always bound humans to nature and the ability to respond to the stimuli that point to the origins of that relationship. We still find the landscapes resembling the African savannah—which has been a human habitat for 2 million years—pleasant and reassuring, and we design urban green areas following the same pattern: low and ordered vegetation, with small woods and large isolated trees (Barbiero and Berto 2016).

Architecture has often contributed to distancing humans from nature through the use of artificial and predictable forms. This has, in turn, generated the illusion of relegating nature to parks, forests, and natural reserves: one could think, for example, of the strict geometric rules of modern architecture, which often overlook the relation of buildings with the natural world within which they are placed. In addition, the quality of the built environment in contemporary cities has emphasised the isolation of individuals from the experience of natural systems and

processes (Kellert 2005). In fairness, the relationship that links human beings to nature cannot be reduced to a subject/object relationship, as humans are part of the same nature that they seeks to reduce to an object (Cesario 2014). In this sense, nature is not only irrational or otherwise defined in opposition to a symbolically and spatially codified city, but represents the original context in which humankind is immersed and to which it innately belongs.

Biophilic design, therefore, is based on the attempt to transfer the innate inclination of individuals towards natural systems and processes—biophilia (Kellert et al. 2008)—in the urban project, trying to overcome the difficulties associated both with the ability to understand the true character of this inclination, and the ability to identify innovative approaches that can be used by planners and developers. Kellert has identified two main dimensions of biophilic design: the organic or naturalistic dimensions (the forms of the built environment that refer directly, indirectly or symbolically to nature) and a place-based or vernacular dimension (when the built environment or landscape refer to the culture of a given territory). According to Kellert, the two dimensions are linked to six biophilic design elements (environmental features; natural shape and forms; natural patterns and processes; light and space; place-based relationships; evolved human-nature relationships) which are in turn found in more than 70 biophilic design attributes (Kellert 2012). This categorisation is certainly evolving and continues to be enriched by the outcomes of studies conducted in different disciplines (just think of *14 Patterns of Biophilic Design*, Browning et al. 2014), but so far it has had the merit of systematising for the first time an innovative approach with the goal of enriching the concept of sustainability and reconnecting the built environment with the well-being of individuals.

Benefits of biophilic design in hospital settings

The positive effects on the health and performance of human beings in response to biophilic design of the built environment have been verified by extensive scientific studies in different settings: healthcare facilities, workplaces, children's spaces, community spaces, etc. The reflection on the principles of biophilic design is particularly interesting when it is applied to healthcare facilities. This is not only due to the high rate of critical and stress factors in hospitals for patients, their families as well as healthcare professionals, but also because the hospital and the city are two separate but interconnected systems, which are visited and used by the same individuals. This relationship is characterised by a certain exceptionality that is precisely due to the isolation of the hospital structure, which is essential to enable the medical practice. The shape of the contemporary hospital has evolved from its initial division into pavilions that almost created a city within the city, to the present-day single-block buildings. This form and organisation have been encouraged and homogenised in Europe since the 1930s with totalitarianism; one may think of the architecture of healthcare facilities during Fascism, in particular tuberculosis sanatoriums to deal with typical poverty-related diseases. These developments have led to the gradual standardisation of healthcare practices for citizens as an affirmation of a democratic principle that was gradually strengthened in Europe since the 1950s, with the introduction of welfare policies. At the same time, the hospital's architectural design has undergone major changes since the second half of the 20th century. These are certainly linked to the role the hospital has in contemporary society, but also to the recovery of values that are no longer just quantitative and functional, contrary to what happened until the first half of the 20th century. These "new values" translate into a "humanised" vision of spaces that, together with the latest technological discoveries and new treatment and care protocols, influence design choices in contemporary hospitals.

In other words, the change in direction happens with the transition from functions to experience, such that the city and the hospital tend to become increasingly similar, not so much for the hospital structure approaching the urban forms but for the inverse process. Architecture and the city enter the hospital redefining the dimension of the hospital through a progressive introduction, in addition to the diagnostic and therapeutic functions, of commercial, informational and recreational features that have redefined the sense of space and the role of the institution in its territory.

One of the first examples of this trend was the Harlem Hospital Pavilion project in New York with the creation, promoted in 1936 by the Works Progress Administration, of murals that depicted the history of working and leisure activities of the African-American population (the African diaspora from 18th-century African village life to slavery in America to 20th-century freedom). The hospital, in fact, plays a catalyst role within the urban environment, strives to reflect the common culture and tries to recuperate it and make it compatible with its identity. It therefore reflects the characteristics of the space and time in which it is located.

What clearly emerges in the historical and social evolution of hospital design and its relationship with the urban space and the people living in it and passing through it is that the hospital is a privileged place of research to highlight not only the advancement of scientific and medical knowledge (and how these affect quality of life indicators), but also the change in the relationship between humans, the built environment and nature.

However, this is a slow and inconsistent process often determined more by far-sighted physicians and the management of individual hospitals, than by a shared and repeatable approach to space design. This scenario reflects the ever-increasing polarisation between large hospitals with highly qualified staff and specialised equipment, where, at the same time, it is often possible to obtain a comfortable environment for the well-being of patients; and small local hospitals that have limited operating and diagnostic capabilities and are only peripheral nodes in the public healthcare network.

As a matter of fact, in most cases, the design of modern hospitals is still geared towards defining spaces in which the only design goal is the precise definition of environments that ensure the proper operation of clinical and surgical procedures, and only in the best-case scenarios, efficient organisational and administrative functions. Hospital architecture often still reflects medical and healthcare practices from the past: these technically and scientifically complex environments are characterised by information asymmetry, which at the same time expresses and defines the relationship between doctors and patients; this asymmetry emerges from a system of temporal and spatial rules that often sees users confused and disoriented, in a state of psychological inferiority to healthcare staff and the care environment in general. At the same time, hospitals are a crucial element of the public healthcare system, both from an economic and organisational standpoint, and from a symbolic point of view, as recognisable institutions in the community.

In fact, since the days of Cà Granda di Filarete in Milan or of Brunelleschi's Ospedale degli Innocenti in Florence, the hospital is not only an expression of the culture and sensitivity of designers, but also expresses a symbolic value attributed to it by the community that it is home to, which defines it as a monument, with a precise identity within the urban fabric. This symbolic value coincides with the functional and physical value given by the form, the materials and the internal order. After all, since as early as the Middle Ages, the life of the city itself has been revolving around the hospital in a mixture of religious, civil, ethical, political, economic and financial interests (Bevilacqua 2017).

The hospital remains a place that is not easily permeable to external culture, and despite the interventions of humanisation of spaces aimed at a broader hospitality and the process of interpenetration with the city, it is still a separate world in which the patient fails to fully perceive the organisational rules. At the same time, it is true that the interventions of humanisation have introduced the value of beauty and the recovery of the relationship between humans and nature in the architecture of the hospital, alongside the more economical and social factors. A beauty understood not as an end, from a Kantian perspective, but as an ethical way to allow the individual, as a temporary guest of the hospital, to accept the set of space-time rules that regulate it and be in an emotional condition that facilitates recovery and care (Tartaglia 2009).

A place perceived as dialogic, welcoming, understandable, aesthetically attractive and relaxing promotes the development of a greater sense of trust and activates a positive feedback to the information and the stimulations coming from outside. Stress factors for patients in therapeutic environments are generally related to the inability to control the surroundings, especially in terms of physical and organisational spaces and timings of the place of care. Other stress factors include the lack of privacy, the presence of unfamiliar and often disturbing or potentially anxiogenic sounds and noises, artificial lighting with a low comfort level, and intense environmental smells, which are often familiar due to the association in the lives of most people with the experience of illness.

Design has only recently started to adopt the patients' point of view, considering not only their physical, but also their social and psychological needs; this has prompted interventions aimed at enhancing the physical, sensory and psychological comfort, improving wayfinding systems and increasing the clarity of the meanings communicated by space design.

Modifying hospitals' design by humanising spaces and especially through reconnecting with nature offers a therapeutic support that can positively impact on the patients' psychological and physical well-being; it can also improve their ability to recover, with varying results depending on the different levels of treatment (diagnosis, therapy, recovery) and on the disease in question. At the same time, space design can improve the efficiency levels of an organisation and contribute to economic benefits, both because the staff's well-being increases, and because it reduces health-related costs. Rooms with plants (especially roses), natural ventilation and light, the sight of, and contact with, nature increase the staff's productivity and organisational capability. These biophilic design choices also boost the activity of the parasympathetic nervous system, thereby decreasing stress levels and encouraging a general sense of well-being. By promoting staff's health, biophilic design helps to reduce sick leave, while improving satisfaction and attention levels (Browning et al. 2012; Heerwagen 2000; Raanaas et al. 2011; Ikei et al. 2014; Nieuwenhuis et al. 2014).

Moreover, extensive research that is supported by rigourous empirical data has shown that the beneficial effects of biophilic design are not only found through architectural solutions that encourage direct contact with the external natural environment, but are also obtainable

by inserting green or elements of biophilic design within the interior spaces. Such interventions, especially if integrated, allow patients to better manage their emotions, fears and anxieties related to disease. Positive effects have also been verified from the physical standpoint.

One of the earliest studies on the subject was conducted by Ulrich in the 1980s. From an analysis of the medical records of some surgical patients in a Pennsylvania hospital between 1972 and 1981, Ulrich noted that those who could see from their window a natural landscape had significant beneficial effects. In particular, patients with a room overlooking a green area had a shorter post-operation hospitalisation and lower use of analgesics compared to patients who were in similar rooms, but overlooking a built environment. According to Ulrich's research, looking at greenery and nature reduces hospitalisation time by 8% (Ulrich 1984).

Subsequent international studies have confirmed that 95% of patients and families exposed to direct contact with nature reported lowered stress levels, more positive thoughts and increased coping ability (Marcus and Barnes 1995). In addition, plants in rooms and rooftop gardens in hospitals improve patients' psychological response to treatment, with lower levels of pain, anxiety and fatigue (Park and Mattson 2008; Matsunaga et al. 2011). Fractal structures and, more generally, natural patterns and shapes instigate a reduction of stress levels due to the stimulation of μ-opioid receptors, which are responsible for pleasure (Biederman and Vessel 2006).

Natural light affects serotonin levels, inducing a lessened perception of pain in patients. A 22% reduction in the use of analgesics and a 21% drop in healthcare costs was observed. Moreover, natural light has positive effects on patients undergoing chemotherapy (Walch et al. 2005; Liu et al. 2005).

Several studies have also demonstrated that the use of natural materials improves the patients' perception of environmental quality and their recovery from illness. This is because natural materials enhance visual comfort (as they absorb more light than they reflect), and have positive effects on olfactory comfort (for instance through essential wood oils), creativity, overall health and the immune system (Tsunetsugu et al. 2013; Li 2010; McCoy and Evans 2002).

The results of these research projects contribute to defining the concept of "humanisation" of hospitals as "a therapeutic practice that leads to looking at the patient taking fully into account the person's integrity, encouraging his or her participatory and active role in the therapeutic path and in the social structure of the hospital" (Spinelli et al. 1994). The humanisation of hospitals therefore involves the design of interventions aimed at redefining the environment both with regard to the organisational and therapeutic aspect, and, more generally, to how the hospital is experienced by patients and visitors.

The Scottish painter, writer and landscapist Maggie Keswick was a great believer in the importance of attending to the needs related to the psychophysical well-being of patients, especially in the case of degenerative diseases. She was determined to make the experience of her own illness the manifesto of a revolutionary cultural change. In the last few months of her life, she worked with Frank Gehry to the design of the *Cancer Caring Centers* that now carry her name. In her view, the patient needs psychological support and therapies that can reduce and mitigate stress, in addition to seeking a cosy atmosphere, spaces full of light and contact with nature. The aesthetic quality of the hospital can therefore help patients to better endure their disease. Many archistars have designed *Maggie's Centers* pro bono: Frank Gehry has designed the center in Dundee, Scotland, Zaha Hadid the Kirkcaldy Fife near Edinburgh, Roger Stirk Harbour and landscape designer Dan Pearson have conceived London's Maggie's Center and many more have been created in recent years.

What is striking in Keswick's words is the narration of space and the surrounding environment. Hospitals can often go against the needs of their visitors: lighting from above (sometimes even neon lights), indoor spaces with no outside view and scarce seating, often placed along the walls and increasing the levels of mental and physical stress of patients (Jencks and Heathcote 2010).

However, biophilic design is much more complex than a window overlooking nature or the presence of plants in the waiting halls or inside the hospital rooms. Recently, *14 Patterns of Biophilic Design* (Browning et al. 2014) identified a broad view of biophilic design tools and applications as well as opportunities to increase the health and well-being of individuals for the different care levels (stress reduction, cognitive performance and emotion and mood enhancement).

In particular, when it comes to biophilic design, it is possible to convey or promote different types of experiences within hospital spaces. According to Browning et al. the 14 biophilic design patterns can be organized into three categories to illustrate the enhancement of user experience and its biological responses, and potential impacts in different care levels: nature in the space, natural analogues and nature of the space. First, the direct experience of nature (nature in the space) that refers to real contact with nature in the built environment, such as the presence of natural light (positively impacted circadian system functioning, Figueiro et al. 2011; Beckett and Roden 2009), thermal and airflow variability (positively impacted comfort and well-being, Heerwagen 2006; Tham and Willem 2005; positively

impacted concentration, Hartig et al. 2003), presence of water (reduced stress, increased feeling of tranquillity, lower heart rate and blood pressure, Alvarsson and Wiens 2010; Pheasant et al. 2010; Biederman and Vessel 2006), or the visual connection with nature for instance through abundance of plants and vegetation indoors or view of natural landscapes (lowered blood pressure and heart rate, Brown et al. 2013; van den Berg et al. 2007; Tsunetsugu and Miyazaki 2005).

It is also possible to conceive interventions aimed at facilitating an indirect experience of nature, referring to the contact with the representation or the image of nature or the exposure of individuals to particular patterns and processes that are typical of the natural world (natural analogues). This type of experience refers to the use of natural materials, the choice of colours that are typical of the natural world, the reproduction of natural forms (decreased diastolic blood pressure, Tsunetsugu et al. 2007; improved creative performance, Lichtenfeld et al. 2012).

Lastly, the nature of the space can affect the experience of patients and visitors through spaces and places. In fact, biophilic design can influence the relationship between the hospital environment and its users, producing positive effects on human health and the feeling of well-being. This can be achieved, for instance, through the use of perspective in interior spaces (which amplifies the perception of the surrounding space), while at the same time conveying a sense of protection (reduced stress, Grahn and Stigsdotter 2010). Other means to ensure patients' comfort include the proper design of the organised complexity found in hospitals: due to their functions and roles, hospitals are by their very nature complex spaces; however, patients and visitors should perceive that they are organised in such a way that the options and opportunities available to them are presented in clear, understandable and consistent manners, e.g. by means of effective orientation and wayfinding systems that should ensure informative comfort.

Browning et al.'s classification of the nature-design relationship applied to hospital design provides a useful framework to understand how to best systematically integrate the individual's experience into the design process and the benefits that derive from it.

However, the analysis of the relationship between the individuals and the hospital space must also consider a further pattern (Downton et al. 2016, 2017). Virtual connection with nature represents the pattern that can provide an increasingly immersive experience of nature, thanks to technological innovation that in the last few years has brought the use of advanced virtual reality (VR) tools to the consumer market.

Up to the present day, the main applications of VR envisaged in the medical domain concerned typically surgical training, post-stroke rehabilitation and the treatment of post-traumatic stress disorder. Ongoing studies aim at defining a methodology for integrating VR into biophilic design (including personalised options) in treatment settings (for example, in Italy the project *Exploring the therapeutic benefits of biophilic design in hospital settings*, carried out by ReLab and Fondazione Policlinico Universitario A. Gemelli, Rome, 2017). As a matter of fact, it is necessary to define and measure the positive effects of the artificial connection with nature and its processes on the patients' well-being, depending on the various conditions, both with regard to distraction capacity, and pain reduction.

Conclusions

In 1859, Florence Nightingale was already talking about the positive effect of light, colour and hospital environment on the body—and therefore on the illness—and not just on the minds of patients. However, although extensive scientific literature has demonstrated a very tight link between the environment and the increase in the effectiveness of treatment, still little attention is paid to the design quality of hospital facilities (Rosen 1993).

The hospital is not just a place of therapeutic knowledge, research and technological innovation, but also a place where professional and human relationships are activated. The final report of the World Health Organization, UNICEF (1978) specifies in the first chapter: "The Conference strongly reaffirms that health, which is a state of complete physical, mental and social wellbeing, and not merely the absence of disease or infirmity, is a fundamental human right and that the attainment of the highest possible level of health is a most important world-wide social goal whose realization requires the action of many other social and economic sectors in addition to the health sector".

Already then, there was a strong belief in the necessity of producing a change in the organisation of healthcare services through an approach that considered human needs in their entirety and not merely with respect to the treatment of the disease in a strictly therapeutic sense. The humanisation process of healthcare spaces, as highlighted above, entails the adherence to a holistic approach that considers people, spaces and activities not only as individual components of a system, but rather as elements in relation to each other. The hospital's architectural design incorporates a vision of the future of healthcare that needs to consider what care could or should be.

In most cases, however, there is no innovative architectural design that looks at how spaces contribute to the conceptualisation of the disease and how they affect the

daily actions of residents and visitors, and that is capable of supporting the well-being of patients through the attention to multisensoriality and the integration of natural elements.

In the last few years, several projects have envisaged hospitals not only as containers of functions, but also as expressions of cultural and social value. However, many of these new projects and of those that have been conducted since the 1990s seem to speak a double language. On the one hand, the language of space aesthetics, that aims to create a comfortable environment, more or less dependent on evidence-based design and biophilic design; on the other hand, the language of medical science that dictates the necessity for sterile and efficient spaces, that do not consider patients' emotional needs.

Still, the opposition of medical science clashes with the new patient-centred approach, which sees patients as "competent" subjects within the therapeutic relationship, who exert their right to be satisfied in their roles as guests/clients, both in terms of the diagnosis and treatment that they receive, and in terms of their expectations related to comfortable clinical and hospital spaces.

As a consequence, the present time does not seem to be able to define a prevalent typological model. Ironically, the last typological model that could clearly express its identity within the urban structure was the one of soulless, efficient and alienating megastructures of the second half of the 20th century.

Otherwise, if we also include projects that were never completed, one could think of Le Corbusier's New Venice hospital project. Today, the landscape is quite complex and shows models of the recent past, maybe partly updated especially in connection with existing buildings, along with new trends and experimental projects, that however do not point in a single direction.

In contrast, what one can actually see is a wide range of experiences, that are more or less influenced by scientific evidence, spanning the gamut from space humanisation (certainly not a new concept, but that is reinterpreted over time according to the prevailing culture), to the idea that cures and therapies are a form of consumption (and, at times, of luxury consumption), to the attempt to use the architectural project to reconnect humans with nature to improve psychological and physical well-being, to performative and sensory design.

However, what is missing is an overall notion of healthcare and, therefore, in some cases, of the very identity and of the role of the institution as it is perceived by the population. But, above all, what is needed is the awareness that biophilic design is not only about integrating plants into the built environment (for example, green walls, green roofs, plants in rooms, etc.), but consists of a more complex experience (as clearly shown by Browning et al.'s 14 patterns) that is founded on the correct understanding of the human–nature relationship.

Authors' contributions
The author read and approved the final manuscript.

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References

Alvarsson J, Wiens Nilsson S (2010) Stress recovery during exposure to nature sound and environmental noise. Int J Environ Res Public Health 7(3):1036–1046

Barbiero G, Berto R (2016) Introduzione alla biofilia. Carocci, Roma

Beckett M, Roden LC (2009) Mechanisms by which circadian rhythm disruption may lead to cancer. S Afr J Sci 105:415–420

Benyus J (1997) Biomimicry innovation inspired by nature. Harper Perennial, New York

Bevilacqua P (2017) Felicità d'Italia. Laterza, Bari

Biederman I, Vessel EA (2006) Perceptual pleasure and the brain: a novel theory explains why the brain craves information and seeks it through the senses. Am Sci 94:247–253

Brown DK, Barton JL, Gladwell VF (2013) Viewing nature scenes positively affects recovery of autonomic function following acute mental stress. Environ Sci Technol 47:5562–5569

Browning B, Garvin C, Ryan C, et al (2012) The economics of biophilia—why designing with nature in mind makes financial sense. Available via DIALOG: http://www.terrapinbrightgreen.com/report/economics-of-biophilia/. Accessed 29 Sept 2017

Browning WD, Ryan CO, Clancy JO (2014) 14 patterns of biophilic design. Available via DIALOG: http://www.terrapinbrightgreen.com/wp-content/uploads/2014/04/14-Patterns-of-Biophilic-Design-Terrapin-2014e.pdf. Accessed 15 Sept 2017

Carson R (1998) The sense of wonder. HarperCollins, New York

Cesario M (2014) Nature et architecture: le sens phénoménologique de l'habiter. In: Younès C, Bonnaud X (eds) Perception, architecture, urbain. Infolio Éditions, Gollion
Downton P, Jones DS, Zeunert J (2016) Creating healthy places, Melbourne Metro, Docklands, Melbourne
Downton P, David J, Zeunert J, Roös P (2017) Biophilic design applications: putting theory and patterns into built environment practice. In: The International conference on design and technology, KEG. pp 59–65. https://doi.org/10.18502/keg.v2i2.596
Figueiro MG, Brons JA, Plitnick B, Donlan B, Leslie RP, Rea MS (2011) Measuring circadian light and its impact on adolescents. Light Res Technol 43(2):201–215
Grahn P, Stigsdotter UK (2010) The relation between perceived sensory dimensions of urban green space and stress restoration. Landsc Urban Plan 94:264–275
Hartig T, Evans GW, Jamner LD, Davis DS, Gärling T (2003) Tracking restoration in natural and urban field settings. J Environ Psychol 23:109–123
Heerwagen J (2000) Green buildings, organizational success and occupant productivity. Build Res Inf 28:353–367
Heerwagen JH (2006) Investing in people: the social benefits of sustainable design. Rethinking sustainable construction. Sarasota pp 19–22
Hickman C (2013) Therapeutic landscape. A history of English hospital gardens since 1800. Manchester University Press, New York
Ikei H, Komatsu M, Song CR et al (2014) The physiological and psychological relaxing effects of viewing rose flowers in office workers. J Physiol Anthropol 33:1–5
Jencks C, Heathcote E (2010) The architecture of hope: Maggie's cancer caring centres. Frances Lincoln Ltd., London
Kellert SR (2005) Building of life. Designing and understanding the human-nature connection. Island Press, Washington
Kellert SR (2012) Birthright. People and nature in the modern world. Yale University Press, London
Kellert SR, Heerwagen JH, Mador ML (2008) Biophilic design. The theory, science and practice of bringing buildings to life. Wiley, New York
Li Q (2010) Effect of forest bathing trips on human immune function. Environ Health Prev Med 15(1):9–17
Lichtenfeld S, Elliot AJ, Maier MA, Pekrun R (2012) Fertile green: green facilitates creative performance. Pers Soc Psychol Bull 38(6):784–797
Liu L, Marler M, Parker BA, Jones V, Johnson S, Cohen-Zion M, Fiorentino L, Sadler GR, Ancoli-Israel S (2005) The relationship between fatigue and light exposure during chemotherapy. Support Care Cancer 13:1010–1017
Marcus CC, Barnes M (1995) Gardens in healthcare facilities: uses, therapeutic benefits, and design recommendations. The Center for Health Design, Concord
Matsunaga K, Park BJ, Kobayashi H et al (2011) Physiologically relaxing effect of a hospital rooftop forest on older women requiring care. J Am Geriatr Soc 59:2162–2163
McCoy JM, Evans G (2002) The potential role of the physical environment in fostering creativity. Creativity Res J 14(3-4):409–426
Mumford L (2007) La cultura delle città. Einaudi, Torino
Nieuwenhuis M, Knight C, Postmes T et al (2014) The relative benefits of green versus lean office space: three field experiments. J Exp Psychol Appl 20:199–214
Park SH, Mattson RH (2008) Effects of flowering and foliage plants in hospital rooms on patients recovering from abdominal surgery. Horttechnology 18:563–568
Pheasant RJ, Fisher MN, Watts GR, Whitaker DJ, Horoshenkov KV (2010) The importance of auditory visual interaction in the construction of 'Tranquil Space'. J Environ Psychol 30:501–509
World Health Organization, UNICEF (1978) International conference on primary health care alma-ata, USSR, 6-12 September 1978. World Health Organization, Geneva
Raanaas RK, Evensen KH, Rich D et al (2011) Benefits of indoor plants on attention capacity in an office setting. J Environ Psychol 31:99–105
Rosen G (1993) A history of public health. John Hopkins University Press, Baltimora **(Cit. in Costello J, Haggart M (2003) Public Health and Society. Palgrave Macmillan, New York)**
Scandurra E (2001) Gli storni e l'urbanista. Progettare nella contemporaneità. Meltemi Editore, Roma
Spinelli F, Bellini E, Bocci P, Fossati R (1994) Lo spazio terapeutico. Un metodo per il progetto di umanizzazione degli spazi ospedalieri. Alinea Editrice, Firenze
Tartaglia F (2009) Estetica sanitaria. Oltre il marketing sanitario. Libreria Universitaria, Padova
Tham KW, Willem HC (2005) Temperature and ventilation effects on performance and neurobehavioral related symptoms of tropically acclimatized call center operators near thermal neutrality. ASHRAE Trans 111:687–698
Totaforti S (2017) Città creativa, città biofilica. Integrare la natura nel progetto urbano. In: Galdini R, Marata A (eds) La città creativa. Spazi pubblici e luoghi della quotidianità. CNAPPC. Available via DIALOG: http://www.cittacreative.eu/wp-content/uploads/2017/04/La_città_creativa_2017.pdf. Accessed 15 Nov 2017
Tsunetsugu Y, Miyazaki Y (2005) Measurement of absolute hemoglobin concentrations of prefrontal region by near infrared time resolved spectroscopy: examples of experiments and prospects. J Physiol Anthropol Appl Hum Sci 24(4):469–472
Tsunetsugu Y, Miyazaki Y, Sato H (2007) Physiological effects in humans induced by the visual stimulation of room interiors with different wood quantities. J Wood Sci 53(1):11–16
Tsunetsugu Y et al (2013) Physiological and psychological effects of viewing urban forest landscapes assessed by multiple measurements. Landsc Urban Plan 113:90–93
Ulrich RS (1984) View through a window may influence recovery from surgery. Science 224:420–421
van den Berg AE, Hartig T, Staats H (2007) Preference for nature in urbanized societies: stress, restoration, and the pursuit of sustainability. J Soc Issues 63(1):79–96
Wackernagel M, Rees WE (1996) Our ecological footprint: reducing human impact on the earth. New Society Publishers, Gabriola Island, British Columbia
Walch JM, Rabin BS, Day R, Williams JN, Choi K, Kang JD (2005) The effect of sunlight on post-operative analgesic medication usage: a prospective study of patients undergoing spinal surgery. Psychosom Med 67:156–163