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Mediterranean Architecture and the Green-Digital Transition

Selected Papers from the World Renewable Energy Congress Med Green Forum 2022

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Contents

Building a Healthier Living Environment for People and the Planet: A Case Study Review

Livia Calcagni and Alberto Calenzo

1 Introduction

Worldwide forecasts estimate that 6 out of 10 people will live in cities by 2030 [1], a figure that will reach 7 out of 10 by 2050 [2]. This progressive increase has led the scientific community to explore and assess the salutogenic effects linked to urban environment and buildings [3]. The paradigmatic shift from health as the simple absence of disease to a state of physical, mental, and social well-being has broadened the disciplinary domain of health to the field of architecture and urban environment. In particular, indoor building-related factors that influence health, well-being, and productivity [4] take on significant importance if we consider that we spend 90% of our time indoors [5–7].

These factors embrace environmental hazards (radiological, chemical, biological, physical) [8], building design, (ventilation, pressurization, filtration, lighting, acoustics) [9, 10], social factors (location, safety) [11], behavioral factors (curriculum, work activities, wellness programs) [12], adjacent land use (chemical releases, walkability, noise sources, green spaces) [13], architectural design (physical activity promotion, eating spaces, material selection, biophilic design, and access to natural lighting) [14, 15], and operations and maintenance (preventative maintenance upkeep, cleaning, integrated pest management) [16, 17]. Other potential health threats due to indoor exposure, mentioned in literature, include radon and lung cancer [18], phthalates and asthma [19], second-hand smoke and increased risk of premature death [20]. All these socioeconomic, behavioral, environmental, genetic, and health factors which have significant effects on health can be described as the

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"social determinants of health," as identified by Dahlgren and Whitehead [21] and further developed in Barton and Grant Settlement health map. The determinants of health are the ones that affect the prevalence of NCDs (noncommunicable diseases), which currently account for 86% of deaths and 77% of illnesses in European regions [22].

The adoption of a salutogenic approach, which envisages preventive strategies and measures that reduce the incidence of disease in the first place, requires addressing urban welfare and health in a transdisciplinary way, as major international institutions are doing. For instance, the Agenda 2030 Sustainable Development Goals represent a unique opportunity to promote urban health through an integrated approach to public policies across different sectors. Although health has a central and own position in the agenda (SDG 3), it is closely linked to over a dozen targets in other goals related to urban health, and its achievement will depend on progress in other SDGs that directly impact health [23]: SDG 1 (no poverty), SDG 2 (zero hunger), 5 (gender equality), 6 (clean water and sanitation), 7 (affordable and clean energy), 9 (industry, innovation and infrastructure), 11 (sustainable cities), 12 (responsible consumption and production), 13 (climate action), and 15 (life on land).

The broad alignment of environmental and health agendas underlines the close relationship that occurs between healthy and green environment/building. By definition, green buildings focus on minimizing environmental impacts through reductions in energy usage, water usage, waste production, and CO_2 emissions. Less widely recognized is the fact that green buildings also address human health through the design of healthy indoor and outdoor environments. This superimposition of green and healthy concepts requires the adoption of a human-centric approach, where the planet's health is conceived as part of human's health and well-being.

Although considerable literature has been produced regarding these factors, there is no overall integrated framework which organizes all scientific and institutional contributions. This paper attempts to outline and organize what has been identified so far and what standards have been developed. In order to do so, 4 organizations and initiatives—which play a key role in linking building users' health and well-being to building performance and characters—have been analyzed, systematized according to 17 broad parameters, more precisely 8 measurable ones (temperature, sound, lighting, air, water, occupancy, accessibility, pollutants/dusts/pests) and 9 nonmeasurable ones (safety, food, lifestyle, setting, behavioral engagement, nature, ambience, resilience/climate action and social capital).

This has allowed us to compare the main indicators tracked by each initiative and to outline a comprehensive framework of the major indicators that can be found in literature. Following are the 4 literature contributions selected:

- *9 Foundations of Healthy buildings,* Harvard T. H. Chan School of Public Health programme led by Joseph Allen (2017).
- *WHO Housing and health guidelines*, drawn up by the World Health Organization (2018).
- *Better Places for People Programme*, by the World GBC and Green Building Council (2020).
- *Level(s) Framework*, developed by the European Commission (2021).

WELL Building Standards, developed by the International Well Building Institute (2016), represent another significant contribution which has been taken into consideration as it is the first and only standard of its kind that focuses solely on the health and well-being of building occupants. More precisely, WELL identifies 100 performance metrics, design strategies, and policies that can be implemented by the owners, designers, engineers, contractors, users, and operators of a building. Therefore, each parameter within the framework has been studied also under the lens of the WELL Building Standard rating system and associated to its relevant features.

Grounded in the UN Sustainable Development Goals, the developed framework intends to organize the most significant international contributions with the aim of detecting all the different building-related health parameters, encompassing the widest range of areas (Fig. 1a, b) represents a cross-sectoral analysis across the entire building and construction characters and lifestyle, redefining the scope of health for all people and communities, through the identification of broad topics, each articulated in specific parameters.

2 Correlations Between Health and Building-Related Factors

NCDs, noncommunicable diseases, currently account for 86% of deaths and 77% of diseases in European regions [22]. These are all those diseases linked to socioeconomic, cultural, and environmental determinants. The awareness that pollution, sedentariness, poor nutrition, unhealthy living conditions on the one hand, and social exclusion, isolation and dis-empowerment on the other, contribute to the development of mental illnesses and new chronic "epidemics," such as obesity, diabetes, allergies, and respiratory diseases, has drawn attention to the role that urban planning and architectural design can and should play in delivering health improvements by reshaping the urban fabric and confined environments. Comprehensive and interdisciplinary approaches are necessary to meaningfully address the complex issues of human health and well-being. A narrow focus on selected aspects of health is inadequate to the task, since it is often the interactions between multiple environmental factors that have a significant impact on day-to-day health and productivity. A growing body of evidence highlights that improving inhabitants' living conditions not only affects physical and mental health but also maximizes the performance of their indoor activities: sleep, study, work, relaxation, and socialization. Therefore, improving the housing conditions also contributes to productivity and socioeconomic empowerment [24].

As evidenced by the WELL Building Standard, each factor can be ascribed to the human body systems that are intended to benefit from its implementation. Each building-related factor with health effects affects different systems of the human body, involving 10 of the main systems:

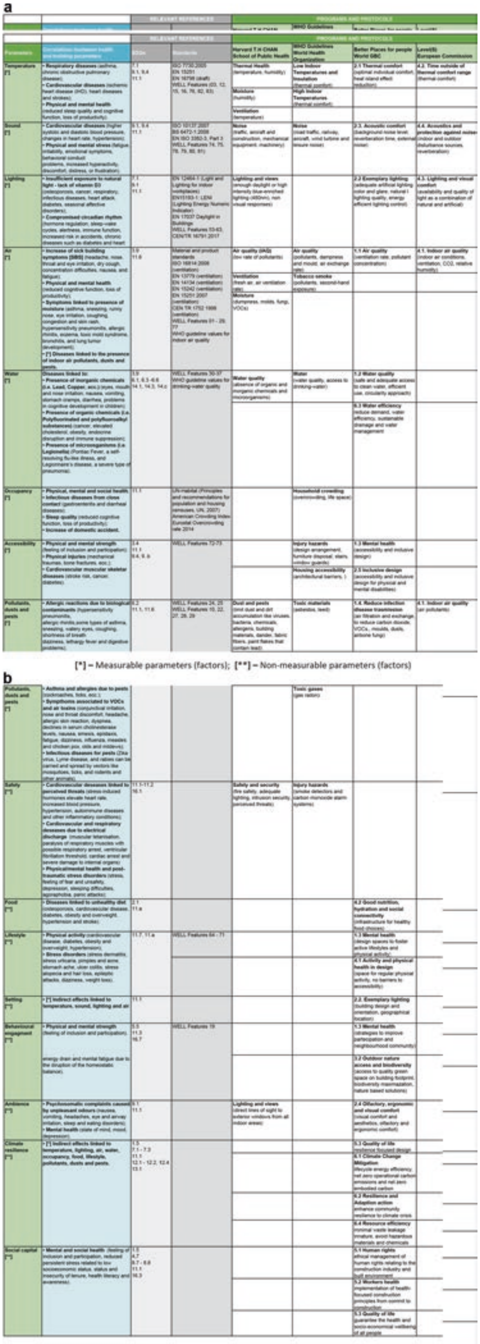

Fig. 1 (**a**) Literature review comparative matrix on building-related health measurable factors. [*] – Measurable parameters (factors); [**] – Nonmeasurable parameters (factors). (**b**) Literature review comparative matrix on building-related health nonmeasurable factors

- *Cardiovascular system* (temperature, safety, accessibility, sound, lighting, food, lifestyle)
- *Digestive system* (temperature, lighting, air, water, occupancy, food, lifestyle, pollutants-dust-pests)
- *Endocrine system* (lighting, food, pollutants-dust-pests, lifestyle, nature)
- *Immune system* (temperature, sound, lighting, air, water, occupancy, safety, setting, food, lifestyle, pollutants-dust-pests, accessibility, climate resilience).
- *Integumentary system* (occupancy, accessibility, air, water, pollutants-dust-pests)
- *Muscular system* (occupancy, accessibility)
- *Nervous system* (temperature, sound, lighting, air, water, occupancy, safety, food, lifestyle, nature, ambience)
- *Reproductive system* (lighting, air, pollutants-dust-pests).
- *Respiratory system* (temperature, air, lifestyle, pollutants-dust-pests, am).
- *Skeletal system* (temperature, lighting, air, safety, accessibility, ambience).
- *Urinary system* (water, food, pollutants-dust-pests).

3 Research Strategy and Methodology

Given the objective to provide an overall knowledge framework and identify invariants and relevant strategies to be adopted in any context to ensure the user's well-being, an analytical framework—which identifies the correlation between strategies and building-related factors—has been created based upon an investigation of case studies that are considered best practices in the field. The selected case studies are considered to be successful projects given their direct effect on occupants' well-being and the positive externalities generated toward their surroundings. The case studies (Figs. 2, 3, 4, 5, 6, 7, 8 and 9) are identified in different geographical and climate contexts and are selected by virtue of their degree of pertinence to a performance-oriented and salutogenic design approach. In particular, eight useful examples of healthy buildings are selected among different functional categories (i.e., residential, public services, offices/schools, and healthcare facilities). In order to address the common reliance on indirect, lagging, and subjective measures of health, the case studies are selected and analyzed according to direct, objective health performance indicators, deduced from a critical synthesis of the most significant contributions found in up-to-date literature. Although the research focuses on a limited number of case studies, the paper reveals some strategies that can be applied to several building in different locations and could be used to support decision makers (DMs) from different countries.

The final purpose of the research is to perform a generalizing and not a particularizing analysis, with the intent to expand and generalize theories (analytic generalization) instead of enumerate frequencies (statistical generalization [25, 26]. According to the case study method, each case study can represent a complete study,

Fig. 2 Case study 1 (CS 1)—Squid Toilet

Fig. 3 Case study 2 (CS 2)—Green (Rose) Toilet

Fig. 4 Case study 3 (CS 3)—Lunder Building

Fig. 5 Case study 4 (CS 4)—Maternity Waiting Village

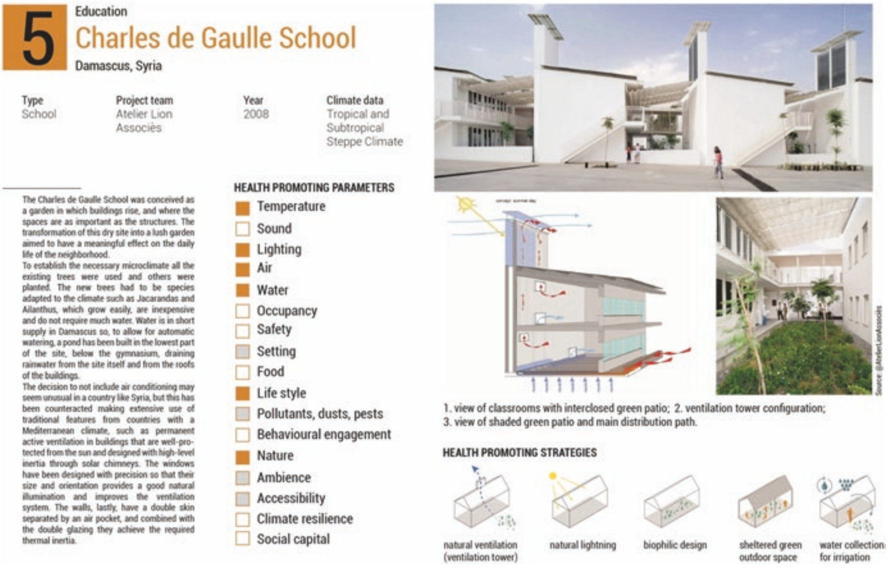

Fig. 6 Case study 5 (CS 5)—Charles de Gaulle School

Fig. 7 Case study 6 (CS 6)—Manitoba Hydro Place

Fig. 8 Case study 7 (CS 7)—Haskell Health House

Fig. 9 Case study 8 (CS 8)—Mariposa District

from which one can detect evidence provided by its conclusions, therefore supporting the overall theory definition.

As these projects show, while the health and climate impacts from building-related factors are not only significant but also complex, the executive strategies are straightforward and can address different issues (factors) simultaneously, proving on a whole the feasibility of implementing simple strategies to obtain great benefits. For instance, simple expedients, such as a detached roof or a porous brick pattern, allow air flows achieving significant ventilation improvements. In turn, natural cross-ventilation contributes to the reduction of moisture and heating as well as to improving air quality. Moreover, requirements associated with one single factor can be satisfied by several strategies, depending also on the specific site conditions. The following parameters described with their relevant strategies referred to the cases study with abbreviation CS, followed by the specific case study number (CS 1, CS 2, etc.).

- *Temperature*: Temperature can be addressed through the implementation of active strategies (radiant floors as in CS 6–7) and passive strategies (ventilation strategies as in CS 5, 6, 7; inner courtyards as in CS 4 and 5, intrusion of nature indoors as atrium garden in CS 3 and 7; optimization of the building envelope performance as in CS 3, 5, 6; shading systems as in CS 4, 6). In CS 1 and 2 temperature control is indirectly ensured by measures related to ventilation.
- *Sound*: Acoustic comfort is guaranteed through appropriately designed internal partition walls in between different environmental units (CS 3) as well as through natural sound barriers placed along the edge of the plot to create a filter with the street (CS 7).
- *Lighting*: A high indoor lighting level and quality can be guaranteed either using a specific construction material such as opaque glass vertical partitions (CS 1), either through a correct sizing and placement of openings according to orientation (CS 3, 5, 6), either by a specific building envelope morphology like the brick pattern of CS 2.
- *Air*: Air quality and good ventilation are satisfied through ventilation towers/ solar chimneys in CS 5, 6, 7, by maximizing natural ventilation through inner courtyard configurations (CS 4, 5) and through sizing and placing of openings (CS 6, 7). In addition, a detached roof as in CS 1 e 2 can ensure air flows and exchange while guaranteeing privacy. For what concerns air quality nature intrusion in indoor environments can contribute significantly to CO_2 sequestration and to the reduction of dust and pests (as in CS 3,5, 6).
- *Water*: Water-related factors, mainly related to water efficiency, and management, are generally addressed through rainwater harvesting, purification, and reuse systems, developed with different techniques in CS 2, 4, and 5. For instance, while in CS 2 and 4, rainwater is collected through simple devices and reused for cleaning and washing purposes, in CS 5, it is the entire site that contributes to the collection. More precisely, a pond has been built in the lowest part of the site, draining rainwater from the site itself and from the roofs of the buildings.

- *Occupancy*: CS 3 provides evidence of how a proxemics-oriented design, which pays particular attention to supplying the entire range of interpersonal spatial zones (intimate, personal, social, public), can affect the occupants' overall well-being, especially within a sanitary facility. CS 8 follows strict rules in the internal layout concerning the number of users per square meter in order to avoid over-crowding conditions.
- *Safety*: Safety in the sense of perceived and actual threats can be addressed through the use of semitransparent exterior walls in the case of CS1. This allows users to check the cleanliness and whether anyone is using the toilet from the outside. Good artificial lighting conditions also contribute to strengthening the feeling of safety in public environments at night (CS 1).
- *Food*: Food production as in healthy nutrition and social connectivity is pursued through onsite cultivation of edible plants as a way to recycle waste products (excrements turned into organic compost) and produce fresh products fostering awareness on the need for a healthy diet in CS 2; as an infrastructure for healthy food choices, self production, and social engagement (urban gardens) in CS 8; and exclusively as a means for a healthy diet in CS 7.
- *Lifestyle*: Shaded and sheltered outdoor spaces (as in CS 4 and 7) foster outdoor activity and social cohesion affecting positively both active lifestyle and social well-being as in sense of community and involvement. Housing units equipped with external appurtenant spaces encourage occupants to spend more time outdoors (CS 7). If internal horizontal and vertical distribution is accessible, visible, attractive, and well-lit (CS 3, 6), users are more likely to be active inside the building integrating physical activity into their everyday routine. Last but not least is the potential of a building to create economical opportunities such as job creation as in CS 2 and 4.
- *Pollutants, dust, pests*: The use of vegetation can affect air quality and therefore contribute to the removal of pollutants, dusts, and pests (as in CS 3, 5, 6, 7). The choice of building components and furniture is crucial as well, as in CS 3, where nontoxic materials are always preferred. Water availability achieved through the additional supply coming from rainwater collection (CS 2, 4 5) ensures a daily cleaning and washing routine and with this a clean environment.
- *Behavioral engagement*: This factor is conceived as the opportunity for the user to interact, in different ways, with the building. In CS 6, occupants can control their individual environment according to their own personal preference using operable windows and lighting and shading devices. It demonstrates how comfort behaviors influence energy consumption. The control the occupants can exert over the environment also influences their perception of comfort. The design and development of CS 8 followed a people-oriented approach by fostering a participatory process that led to the definition of site-specific goals related to the needs of the local citizens. This initiative strongly addressed community engagement, social cohesion, and well-being.
- *Nature*: Biophilic design as in occupant access to nature within indoor environment is achieved through the provision of an atrium garden in CS 3 and 6, through direct access to outdoor quality green spaces (CS 7,8).

- *Ambience*: Considering ambience as a factor that embraces visual comfort (lighting and quality of views), olfactory comfort, and ergonomic issues, several different strategies are adopted. For instance CS 3,4,6,7, although in different ways, guarantee direct lines of sight to exterior windows from more indoor areas as possible. CS 1 and 2, environments which are more likely to smell because of their function, pay special attention to constant air exchange and ventilation.
- *Accessibility*: Inclusive design and accessibility design standards are followed, accordingly with relevant national regulations, in all the projects. In CS 1 special attention is paid also to gender equality as all users have access to the same facilities. In particular, vulnerable environments (such as CS 3) rooms are designed to have soft lighting, specific colors depending on the function, large garden-themed graphics, and both open and intimate spaces to create a sense of calm and mental stability.
- *Climate resilience*: Resource efficiency is achieved through minimal waste leakage in nature, improvements in lifecycle energy efficiency through a combination of active and passive strategies in CS 1, 2, 4, 5, 7, 8.
- *Social value*: The creation of positive social impact implies minimizing construction workers exposure to hazardous materials and toxic substances, creating social and economic opportunities with an indirect impact on health and well-being, such as employment opportunities (CS 1,2,4,6,8) or access to education (CS 2).

4 Conclusion

Literature review reveals how one of the major limitation of the field of study is the reliance on indirect, lagging, and subjective measures of health. Moreover, not all health indicators (factors) are actually measurable. Only a few parameters of indoor environmental quality performance can be measured according to true objective measures of occupant health and standardized health metrics, such as temperature and humidity, air quality and ventilation, sound, lighting, pollutants, dust, and pests concentration. Other parameters, including occupancy, accessibility, and safety, are not strictly measurable but still subject to standardization at the discretion of local regulations. More precisely, some of the parameters which cannot be truly defined as measurable (i.e., lifestyle, safety, food, and nature) are measurable in their effects, for instance, sleep quality, anxiety levels, depression, healthy diet, and statistical incidence of some sub-parameters, but listing them all is beyond the scope of this paper.

Currently, there is still no certified system that defines all the building-related parameters that affect occupants' lives, comfort, and well-being. The WELL Building Standard partly does, but it skips some of the features identified by means of our crosscutting literature review focused on programs and initiatives on healthy buildings. For instance, parameters like occupancy, safety, nature and climate resilience, which are identified—partly by WHO Guidelines and Harvard's Protocol, and entirely by Better Places for People World GBC—are missing. The systematic comparative matrix (Fig. 1a, b) highlights how the perception of well-being must be considered as a multisensorial experience that includes at least thermal comfort, visual comfort, indoor air quality, ventilation, acoustic comfort, and spatial comfort, which are common to all the analyzed programs. Yet it is absolutely necessary to consider, in addition to these purely technical factors, broader and more indirect health related features ranging from the presence of nature (biophilia effect) to behavioral engagement and social capital and many others (safety, accessibility, access to water and food, quality of water and food, active lifestyle, etc.).

The crosscutting literature review as well as the analysis of case studies have highlighted the feasibility of implementing simple strategies to obtain great benefits but at the same time how complex strategies tend to be more capable of satisfying multiple benefits simultaneously. Nevertheless, such results must be tailored to specific contexts from a cultural, social, economic, climate, and microclimate point of view.

In this respect, the "setting" factor, conceived as site-specific design, is only made explicit in the Better Places Programme. The climatic/microclimatic aspects, which are specific to each location, significantly affect the relationship between building and environment. Taking this into account, "setting" should certainly be given greater importance, also by virtue of being a measurable parameter, therefore more suitable to objective post occupancy evaluation, thus to in-progress improvements. Aspects such as building shape and orientation, which differ in different latitudes/longitudes, significantly contribute to maximizing solar radiation and natural ventilation and consequently to improving thermal and visual comfort as well as indoor air quality. A correct interior layout of a building's functions, designed according to the time of use, optimizes the amount of natural daylight supply. Another considerable aspect is the building's form, defined as the ratio of dispersing surface area to heated volume. For example, in climates that tend to be cold, by using more compact shapes, therefore with a low surface area/volume ratio, heat dispersion toward the outdoor environment is limited thanks to a decision made already in the meta-design phase. Conversely, by adopting more articulated and permeable forms that increase the amount of dispersing surface area, the building will have a greater capacity to dissipate heat.

The case study review has also underlined how the indoor living, studying, and working conditions which embrace quality levels of comfort, individual lifestyles, social and community networks, actually affect, also the social, economic, and cultural status of the occupant. These determinants are all among the modifiable determinants susceptible to correction and transformation. The economic value produced by the improvement of some of the parameters can be divided into private and public sector value, ranging from metrics that influence personal financial outcomes, such as decreased healthcare costs or insurance premiums, to ones that relate to the sale or rental value of a property or development. Moreover, at a national scale one could mention also societal outcomes, such as decreased public health costs and increased economic prosperity, through to mortality rates and life expectancy. This reinforces the idea that the benefits of designing homes and neighborhoods for health and well-being can make a difference on many different levels.

Overall, healthy buildings pursue the physical and mental health of the human body under the premise of energy efficiency and environmental regeneration, within the broader approach of people-oriented design. It is likely that healthy buildings will become the new frontier of both the construction industry and institutional policies in the next decades. The improvement of existing and new buildings is a priority in tackling climate change and urbanization but equally a public health concern that requires respective social and equity priorities and that should therefore be of vital interest among policy-makers, the industry, architects and the public health community alike. In order to achieve this, future research could lead to the definition of qualitative indicators to measure all the listed building-related parameters.

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