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Original article

Design for all A.U.D.I.T. (Assessment Universal Design & Inclusion Tool). A tool to evaluate physical, sensory-cognitive and social quality in healthcare facilities

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Abstract. *Background and aim:* Universal Design (UD) is the design of environments equally accessible and usable to the wider range of people regardless their abilities or disabilities. Various studies highlight the lack of evaluation tools to support decision makers to enhance inclusive environments, especially complex constructions with various users as healthcare facilities. The research proposes a tool to evaluate the quality of building according to UD through a new set of objective indicators with a performance-based approach. *Methods*: the tool has been developed through three main phases: 1. Analysis of the state of the art through a systematic literature review and workshops with stakeholders and experts; 2. Elaboration of the evaluation framework following the Multicriteria analysis methodology; 3. Application, to test and validate the tool in hospitals. *Results:* the tool, named Design for All A.U.D.I.T., evaluates the level of UD analyzing Physical, Sensory-cognitive, and Social quality through a set of criteria specified by indicators and measurable requirements. The tool assesses the different healthcare environments through criteria and indicators to verify the level of appropriateness in terms of UD. The tool provides report with quantitative, qualitative and graphical information in plan of the facility status and design strategies. *Conclusions:* The study proposes an innovative evaluation system to determine the inclusion of hospitals, both for projects and for existing buildings. The flexible structure allows the tool to be applied in different building typologies, currently adopted to identify hospital's weaknesses and setting priorities of intervention on inclusion. (www.actabiomedica.it)

Key words: Universal Design, Inclusive Design, User-Center design, Hospital, Building performance, Evaluation tool, Rating system

Introduction

1,3 billion people of the world's population has some form of permanent physical, sensory and mental disability (1). This number grows considering "temporary" impairments, as aging (people are living longer), pregnancy or every situation that compromises physical or mental conditions for a period of the life. WHO defined disability in the International Classification of Functioning, Disability and Health (ICF) (2) as the interaction between health status, personal factors and environmental factors. Therefore, every individual could experience "situational" impairments, for example generated by the relation with an un-accessible environment while making a task (e.g. carrying a stroller or a suitcase) or by social barriers for cultural or gender diversity (3).

The common goal of Universal Design (UD) (4), Design for All (DfA) (5) and Inclusive Design (6) is to promote environments that can be used by all the users mentioned above, equally and independently, regardless of age, gender, culture, ability or disability.

These design strategies, originated from different geographical and historical contexts, go beyond the concept of overcoming architectural barriers, to promote activities and services of the society where everyone can take part through same experience of the environment (7).

However, a large number of buildings still fail to provide a satisfactory inclusion experience. Problems of accessibility, wayfinding and comfort still generate disabling situations, with an impact on the wellbeing of the users and the overall quality of service of the facilities.

This is especially true in healthcare environments, as complex structures where a plurality of users with different needs interact (patients, clinicians, technicians, visitors, etc.), which may be amplified for health conditions or in emergency situations with stress and anxiety for work pressure (8). In hospital design, several studies specifically deal about User-Center design (UCD), which is a process with "the user as the center of focus" (9). As UD comes from a huge shift in paradigm from medical to cultural and social approach (10), even UCD derived from a medical approach based on functionality where hospitals were considered as machines to heal and cure the sick. The current approach is based on social aspects where healthcare facilities are spaces for care, research, education, workplaces and health promotion for healthy people (11). Therefore, for UCD particular attention must be paid to the physical, psychological and social needs of all users from patients to staff in the design process of healthcare facilities (12). Even during emergency situation, as learnt from COVID-19, presence of spaces for the physical and psychological well-being is strategic for all users and it also positively influence the work performance of the healthcare staff (13).

The main problem, especially in healthcare facilities, is to integrate UD and UCD with adequate project time and budget. In this sense, it is important to monitor that the upstream planning of the overall projects is coherent to guarantee also the application of aspects related UD. Indeed, different design features can support physical and psychophysical comfort of both patients and staff, as natural elements, natural light, color choices, materials, acoustic insulation, privacy, but also technological elements that allow patients to be in contact with the outside world (14).

The complexity of UD, which encompasses different needs of various users, limits its effective application in the built environment. There is a lack of standardized data types on Universal Design evaluation, so decision makers cannot understand the benefits and impact of this strategy with clear Key Performance Indicators (KPI). Despite growing demand, there are no agreed upon models or methods to evaluate how UD is applied or what outcomes are achieved (15). There is a need of evidence-based tools to support building industry professionals (16) to demonstrate the impact of inclusion on people's well-being and in in collecting and evaluating objective data on UD (17). To date, there are no systems in Europe to assess and certify the inclusion of a building or an environment, in healthcare environment.

Objectives

The research project was developed to make hospitals and healthcare facilities more inclusive and accessible for the great diversity of users, with the aim of ensuring fair access to care and improving the well-being.

From the combination of the previous needs and the gap of evaluation tools and methods, raised a research question. How can a tool to evaluate Universal Design in healthcare facilities be developed and adopted to support decision makers in improving well-being of different users with a performance-based approach?

The objective of the study is to develop an evaluation method to measure spatial, sensorial and social quality of the hospital environment through a rating system based on an evidence-based approach. The tool is meant to support healthcare managers and designers from the beginning of the design phases in the decision-making process, both in hospital design and renovation of specific areas of outdoor and indoor environment, focusing on people needs. In particular, the article describes the development process, methods and characteristics of a performance-based tool developed from a doctoral research (18,19) to evaluate Universal Design in healthcare environments.

Methods

The study uses Multi-Criteria Decision Analysis (MCDA) (20) to structure the complexity of UD, as a methodology to solve complex decisions and planning problems involving multiple qualitative and quantitative data related to a project (21). This approach is used to develop the structure of different tools for building assessment (14), which are based on a hierarchical framework of Criteria and Indicators (C&I type), that are parameters for evaluating a system through quantitative and qualitative measures and representing its main features. The evaluation is therefore characterized by a performance-based approach (18), which focuses on the achievement of objectives, rather than on prescription of rules to follow.

The process of structuring the framework is guided by the MCDA approach three phases (1.Analysis; 2.Elaboration; 3.Application-Validation).

1. *Analysis:*
   - A systematic literature review investigated current and existing studies on UD/DfA evaluation methods and tools, also described in a previous work. The analysis explored existing knowledge on UD assessments gathered from the literature to systematically and scientifically select items for the development of the assessment framework. *Scopus* and *Web of Science* databases provided more than 1,700 scientific contributions. Of the 21 most relevant, the existing evaluation theories, criteria, methods, and tools on UD are analyzed, from which current gaps emerged. The analysis provided data on UD objectives for the categories, criteria and indicators selections and to explores the different existing methods.
   - An analysis of UD tools found and guidelines in relation to healthcare sector is performed, because from the literature review resulted that there are no specific tools for the hospital environment. This analysis was useful to collect data about the indicators and requirements used by existing tools.
   - Five workshops with stakeholders were conducted, in order to support the criteria selection and definition through a participative approach (22). One workshop involved experts (i.e. architects and designers specialized on accessibility and UD) and four users with motor, sight, hearing, or cognitive impairments. Since UD is a discipline based on users' needs, it is fundamental to include a plurality of viewpoints in the framework definition as such accommodates different possible approaches to a problem. The workshops were useful to determine exclusion or overlapping of objectives for an inclusive environment with the criteria in the literature review. In particular, the research proposes the stakeholder analysis (23) to identify which actors should be involved in the workshops and the cognitive mapping technique (24) to organize contents. From the workshop and literature review analysis the framework has been developed.
2. *Elaboration:*
   - The evaluation framework and system were defined following MCDA approach after the selection of data through the literature review and workshops. A hierarchical framework (value tree) has been composed by categories, criteria and indicators and requirements clustered in high-level and lower-level objectives in a hierarchy structure. In particular, the analysis of the evaluation criteria, as UD Principles (25) and UD Goals (26), concerns three main categories: two related to human performances (i.e. physical aspects and sensorial-cognitive aspects) and one focused on social aspects. For this reason, the framework evaluates Physical, Sensory-Cognitive and Social quality (22).
   - Four hospitals analysis have been performed, as case studies to analyze more in depth the relation between the first version of the UD framework and the healthcare environment. The framework

has been used to analyze different spaces of the hospital and to collect more data on the criteria, indicators and requirements' contents in relation to the hospital environment. This empirical analysis supported the analysis of UD guidelines manuals and healthcare assessment tools of the literature. In particular, the following public spaces have been analyzed: outdoor (green areas and paths), entrance (hall or street), circulation (horizontal and vertical), waiting rooms, services (bathrooms, restaurant and canteen). The hospitals included in the study have been chosen because they empathize the attention for patient and staff in their vision, policy or design features.

- The UD assessment framework has been reviewed through interviews with experts on both UD and hospital design. This allows to finalize the first version of the tool based on the knowledge assembled by the evaluation systems analyzed and the experience of previous analysis.

3. *Application and validation*
   - The first version of the tool has been applied to a private hospital in Buffalo (NY) in the public in the public spaces of the four cases studies analysis. The evaluation of the facility through the tool allowed the review the system usability and highlights weaknesses to be fixed.
   - A survey has been developed to compare the tool's analysis in relation to users' experience within the same hospital in Buffalo (NY). The questionnaire has been administrated by the author to 62 visitors (relatives, friends) and 38 staff (physicians, nurses, hospital managers, secretariats, volunteers, security members, technical staff). The items of the survey used to collect the users' perception of the hospital environment, were compared to the requirements of the tool. The comparison provided relevant matches between the survey's responses and the tool objective indicators evaluation, which confirm the reliability of the evaluation system. In addition, the survey can be used as a separate tool evaluate the preference of hospital users.
   - The tool has been reviewed after both the result of the first application and a focus group with experts in UD evaluation. Specific sections on clinical spaces have been integrated (outpatient and inpatient departments).
   - The second version of the tool was validated in the national context, at a private hospital in Milan (Italy), outlooking strengths and weaknesses basing on the obtained results. The analysis included both public and clinical spaces, in particular outpatient and inpatient departments.

The image shows the different steps of the methodology related to the specific result to develop the overall evaluation framework (Figure 1) through the selection and definition of categories, criteria, indicators and requirements. The study, in the following section, describes the final version of the tool to assess and monitor UD in healthcare facilities.

Results

The study outlines an evaluation tool called Design for All A.U.D.I.T. (Assessment Usability Design & Inclusion Tool) to assess Physical, Sensory-Cognitive and Social quality of healthcare facilities. Indeed, as the UN Convention of People with Disability (27) highlights, a person with a disability is only limited in their ability to participate in society as a result of their interaction with barriers that society permits to exist. In this sense, inclusion is a concept also related to social factors, in addition to physical conditions. The indicators propose goals to achieve and assess the features of the space beyond the regulations to overcoming architectural barriers, embracing the different aspects of UD. In this way, the framework clearly defines the relationship between UD goals and outcomes on people's well-being.

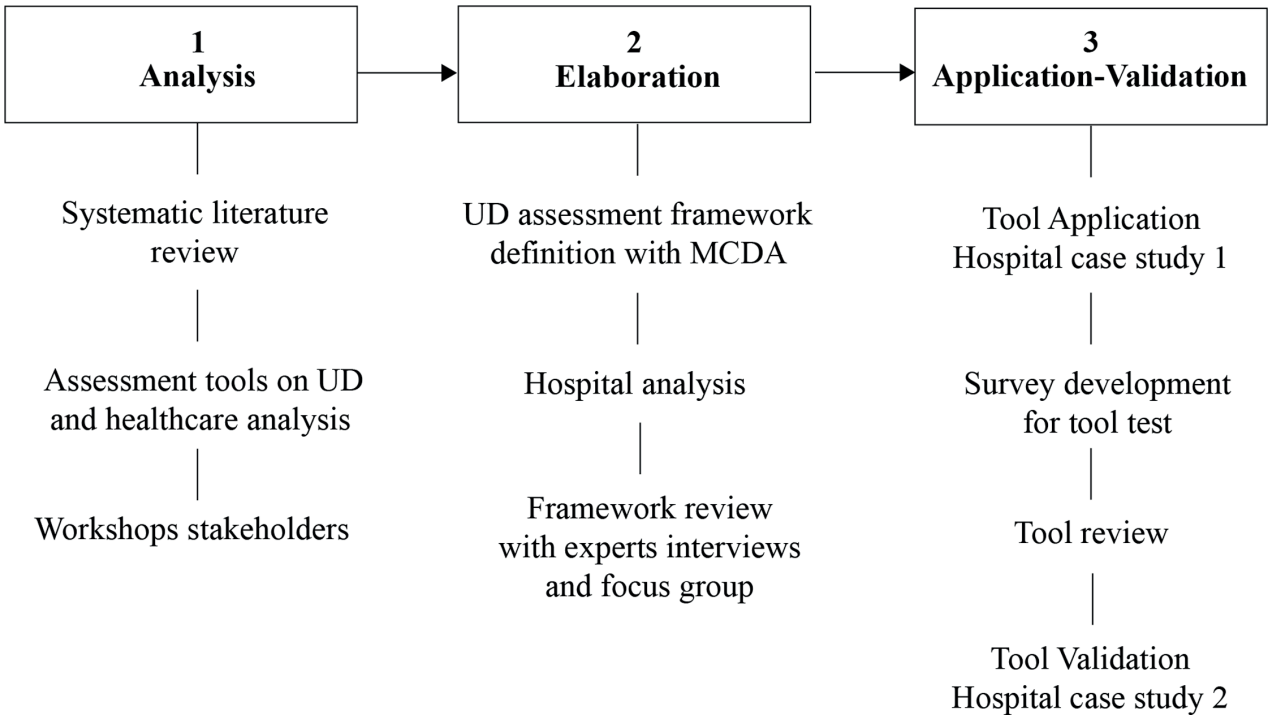

Figure 1. Methods flow chart. Source: authors.

Process

The proposed tool is meant to be used by experts to support decision makers as healthcare managers and designers in taking decisions on universal usability and inclusion, in order to focus the interventions on main priorities. The tool can be applied in different phases for various aims: from the beginning of the design process as a decision support system; after construction as a final certification of the project and when the building is in use as a post-occupancy evaluation method (28) to guide renovation of specific areas and monitor the overall building performance. This is possible because specific indicators are deactivated in the design phases, while all of them are used for the building evaluation.

Regarding the process, the aim is to support achieving UD goals focusing on people needs, from staff to patients and visitors, instead of prescribing design solutions by a performance-based approach. In the evaluation process stakeholders (client, healthcare managers, directors, designers, etc.) are involved at the beginning in a focus group in order to understand their needs; during the site visit to perform an interactive approach and at the end of the process.

Design for All A.U.D.I.T. tool, during post-occupancy evaluations, can be used in combination with a POE Survey to directly involve users in the assessment process. The survey allows to collect information on users' behavior and needs in a specific context, in addition to the evaluation of the tool that focus on design features. The POE survey consists in 90 items grouped in 44 questions that are divided in sections related to the same public environments of the tool (Outdoor Spaces, Entrance, Interior Circulation, Waiting Areas, Bathrooms, Coffee Shops, General Building). The POE survey provides questions to users that include aspects related to Physical, Sensory-cognitive and Social quality. In this way, the Survey allowed to monitor the same aspects evaluated by the objective indicators of Design for All A.U.D.I.T., by looking at the subjective perception of people using the space, as post-occupancy evaluation.

Tool structure

The proposed system uses an algorithm that provides scores reflecting the performance of each space, from the outside of the building to all its interior spaces. The system combines data from a new hierarchical framework of UD indicators (Figure 2) to the different building's environment (outdoor space, entrance, horizontal circulation, vertical circulation, waiting areas, refreshment areas, bathrooms, offices, inpatient department, outpatient department, overall service) (Figure 3). Environments were identified according to the analysis of: accessibility regulations, Universal Design guidelines and tools, which take into account these spaces to provide indications regarding the use of the building by users. In this way, the structure of the tool can evaluate different types of public buildings, because it includes both environments common to all building typologies, and the environments of the specific type of building (e.g. inpatient and outpatient department).

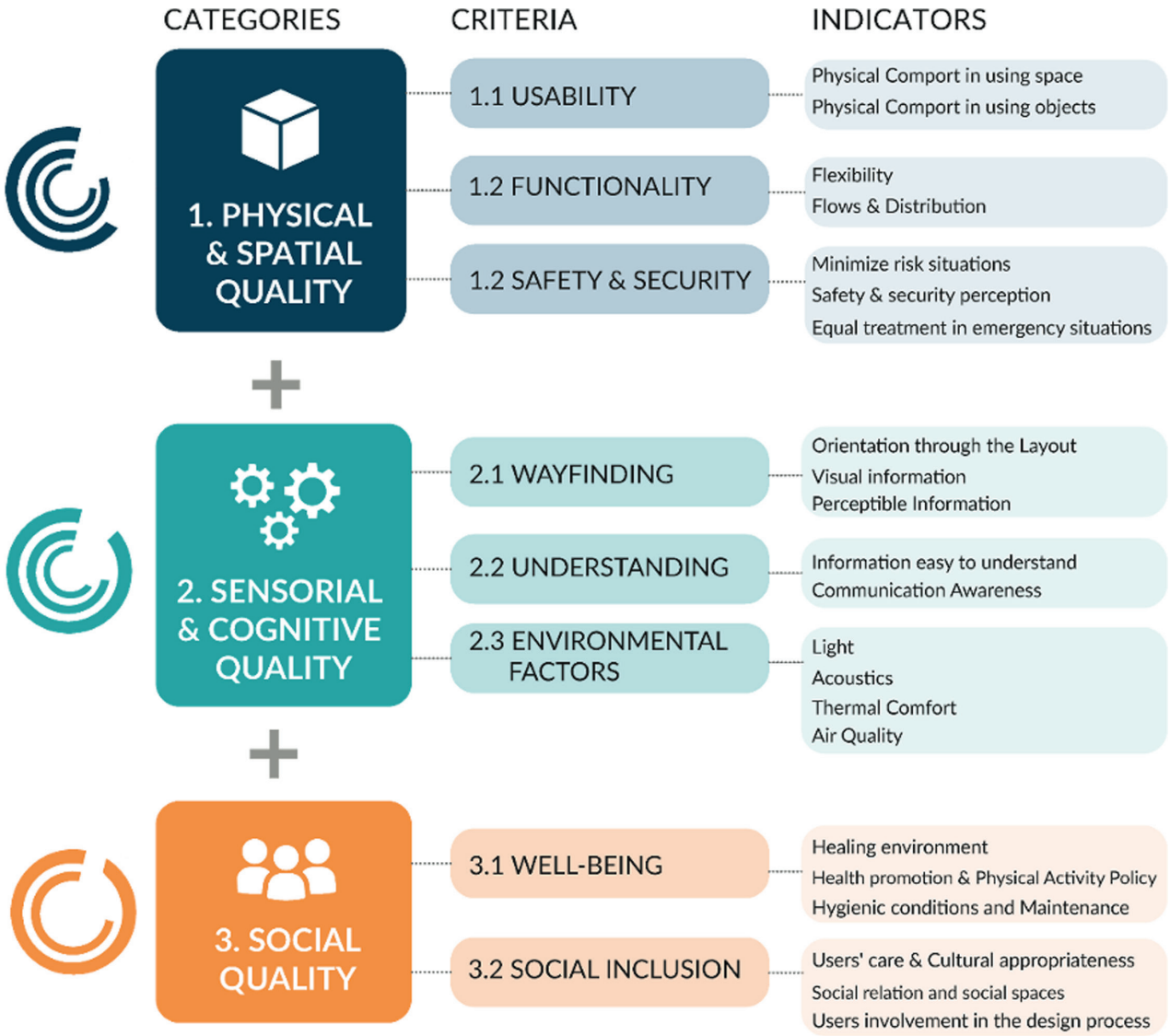

Figure 2. Design for All A.U.D.I.T. assessment framework. Source: authors.

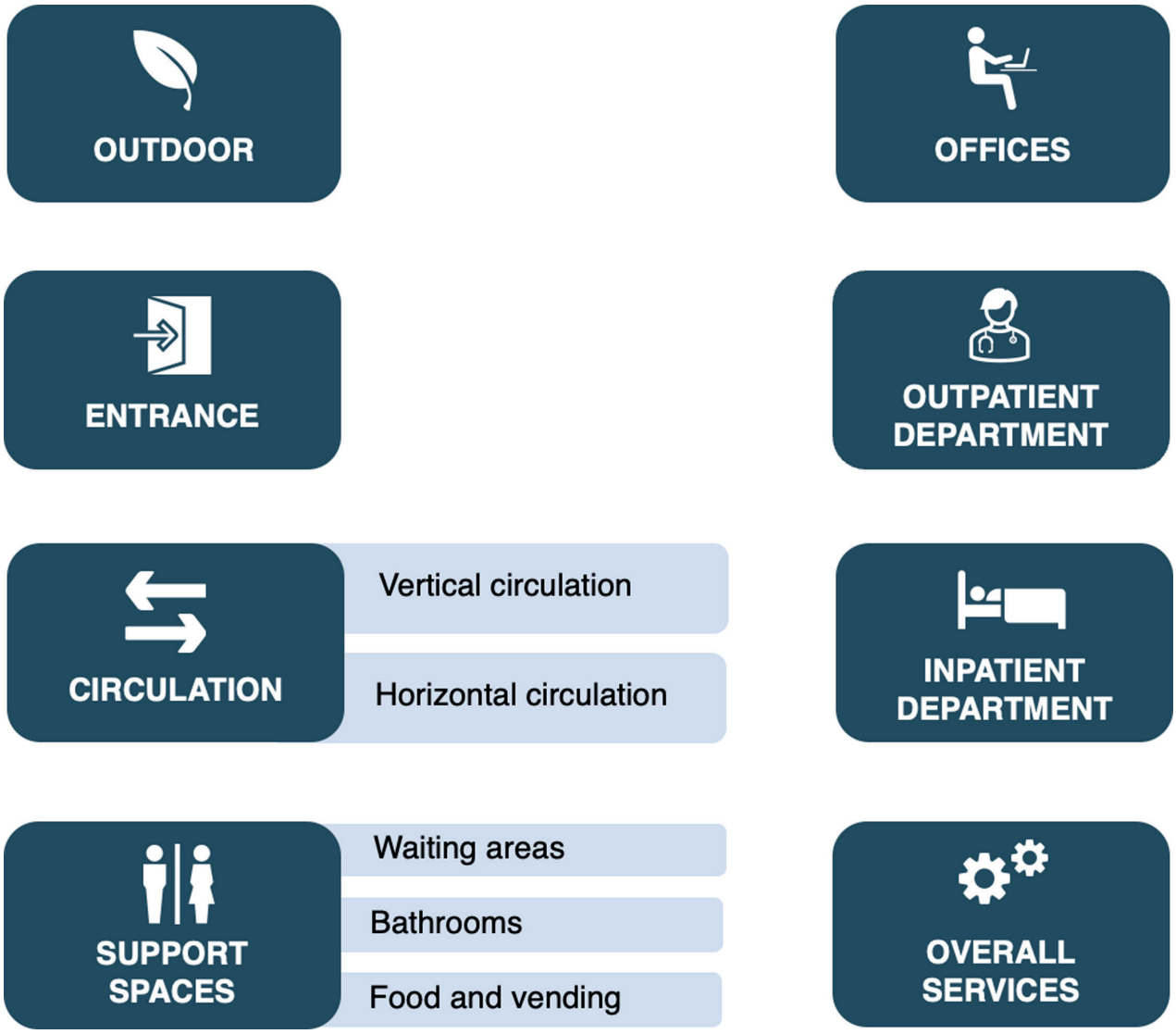

Figure 3. Environments evaluated by Design for All A.U.D.I.T. tool through the framework. Source: authors.

The framework consists of: 3 *Categories* (Physical-spatial quality; Sensory-cognitive and Social); 8 *Criteria* (Usability, Functionality, Safety, Orientation, Understanding, Environmental quality, Well-being, Social inclusion) and 20 *Indicators*, evaluated for each environment through measurement *requirements*. The framework is repeated for each environment maintaining the same structure to allow comparison and data analysis. Only the requirements change for each section (in terms of number and content), because the needs of users change in relation to the circumstances and space settings. In total the tool has 571 requirements, needed to determine a final overall score for the building/project.

Evaluation framework

This paragraph aims to explore more in depth the features included in the assessment framework (Table 1).

The 3 categories are the main thematic area of the evaluation. They have been defined by the

Table 1. Design for All A.U.D.I.T. assessment framework with specific categories, criteria and indicators descriptions.

Categories	Criteria	Indicators
1. Physical quality The category refers to the capability of the environment to foster easy, comfortable, functional and safe use of space and object for every user from patients to the staff.	**1.1 Usability** Ensuring that all clients, medical personnel, and visitors can access and use the environment and products in a comfortable, easy and equitable way, accommodating a wide range of abilities.	*1.1.1 Comfort in using spaces* To promote access and use of the environment in a comfortable, easy and equitable way, in relation to: distances to overcome to reach destination (e.g. department from the entrance), dimensions of the space (in plan and section) for guarantee the movements, materials of the surfaces (e.g. floor). *1.1.2 Comfort in using furniture* To promote use of objects and furniture in a comfortable, easy and equitable way, in relation to the different building features present in a space (e.g. portion of the reception desk at a low height, dimension and usability of doors, handrails, seats, lavatories, etc.).
	1.2 Functionality Allowing flexibility in relation to opportunities for choice and the expression of individual preferences and the flexibility of the space during time. Functionality of the environments in terms of distribution.	*1.2.1 Flexibility* To maximize the flexibility of the space or furniture, which guarantees opportunities for choice and the expression of individual preferences/personalization (e.g. medical equipment accessible for different levels, heigh of a workstation table, different dimensions of seats, etc.). To maximize the flexibility of the space during time, allowing possibilities of adaptation (e.g. possibility to change the environment configuration according to different needs). *1.2.2 Distribution* To maximize the functionality of the environments' distribution and configuration in terms of flows (e.g. staff's flow separated from visitors' flow), proximity relations of different functions (e.g. departments relations).
	1.3 Safety & Security Guaranteeing safety and security in both emergency and common situations for different users, without stigmatized solutions, by minimizing risk situations.	*1.3.1 Minimize risk situations* To reduce or prevent users' exposure to risk generated from the environment and furniture (e.g. prevention of falls, collisions, accidents, work mistakes and glare through contrasting elements). *1.3.2 Safety and security perception* To promote safety and security of individuals and materials through the organization of the people actions in using spaces and furniture; adequate safety and security policies (e.g. use of badge to access to specific departments or technical areas of the hospital, cameras or security to monitor spaces, etc.).
2. Sensory/cognitive quality The category concerns the capability of the environment to foster orientation, comprehension of the service and comfort of users. It refers to the features that impacts on people senses and cognition.	**2.1 Wayfinding** Orienting users through different ways: by visual, tactile and verbal information and by the layout of the building. To determine the own position in a space and find the destination (e.g. departments, exit, office).	*2.1.1 Orientation through the layout* To maximize the possibility to determine the own position in a space and find a destination by means of design features and elements visibility and perception guaranteed by the layout of the space (e.g. reception desk or elevators visible from the entrance). *2.1.2 Visual and perceptible information* To maximize the possibility to determine the own position in a space and find a destination through different ways. To guarantee the orientation for different users' abilities and disabilities using all the five senses in providing information in a visual, tactile and audio way (e.g. signs, colors, map, tactile guidelines, vocal information and sound).

Table 1 (*Continued*)

Categories	Criteria	Indicators
	2.2 Understanding Communicating information in an effective, clear and simple way, regardless of the environmental conditions or the cognitive and sensory abilities of the users, knowledge, cultural and language skills, degree of concentration. Guaranteeing that users can easily navigate the environment without any assistance reduces tension and fear.	*2.2.1 Information is easy to understand* To communicate information in an effective, clear and simple way regardless of the environmental conditions and abilities or disabilities of the users through specific care to the sign legibility (e.g. colorblind glare prevention, color contrast, attention to for colorblindness) and additional information as pictograms, meaning for different units and the use of different languages. *2.2.2 Communication and info awareness* To maximize the possibility for visitors and patients to understand activities that are occurring (e.g. patient journey for a visit, methods and quality of the information for reserve an appointment or obtaining clinical results) and to communicating information in an effective, clear and simple way including also ICT and smart technologies (e.g. website accessibility, mobile app, totem for self-check-in).
	2.3 Environmental factors The evaluation of indoor environmental quality conditions in relation to the impact of all user's comfort by analyzing lighting, acoustics, thermal comfort and air quality and the possibility of some user to control these features in relation to their comfort preferences (e.g. control light, temperature).	*2.3.1 Light* To provide illumination condition that is aimed to provide comfort for users and enhance productivity and provide appropriate visual acuity where needed for staff (e.g. natural light provision, glare obstruction, artificial light intensity, artificial light control system remotely and by users). *2.3.2 Acoustic* To reduce noise sources that may interfere with verbal communication or disturbing concentration and privacy (e.g. measure of dBA, sound reverberation control through acoustic insulation provisions). *2.3.3 Thermal comfort* To enhance thermal comfort to prevent stress and injury and facilitate comfort, productivity and well-being for all users of the building (e.g. relative humidity and temperature control within ranges and thermal comfort system control remotely or by users). *2.3.4 Air quality* To improve and monitor air quality to reduce infection risks with good air quality and proper ventilation air flow within the building (e.g. active and passive ventilation system when possible, control of the system by users, prevention of unpleasant odor).
3. Social quality the ability of the environment to enhance well-being and inclusion. It considers emotional stimuli and social integration among users.	**3.1 Well-being** Fostering well-being through the healing quality of the space to have a positive effect on the psycho-physical well-being. Helping patients' recovery, supporting rest from stress situations and improving staff performance through soft qualities, physical activity promotion and hygienic conditions control.	*3.1.1 Healing environment* To foster wellbeing through the healing quality of the space. Aspects as colors choice, materials, daylight provision, nature, staff spaces for relax and artwork are used to create a pleasant and healing environment for patients' recovery. *3.1.2 Health promotion and physical activity* To provides the opportunities and support for a healthy (e.g. food provision) and active lifestyle and discouraging sedentary behaviors and encouraging active pedestrian activity both outside and inside the building (e.g. accessible and well-maintained outdoor spaces as terraces and gardens, promotion of stairs use instead of elevators, promotion of healthy food options, etc.). *3.1.3 Hygienic conditions and maintenance* To promote environment hygiene and organization for the users in relation to material and space cleanliness and maintenance (e.g. angles between walls and windows/floors are sealed, bathrooms' elements are raised from the ground to allow to clean cleaning).

Table 1 (*Continued*)

Categories	Criteria	Indicators
	3.2 Social inclusion Reinforcing cultural values and the context of any design project, treating all groups with dignity and respect. Promoting active participation for individuals to the activities with others. The design process involves different stakeholders as a support, in order to understand their needs and ideas fostering their achievement in the design practice.	*3.2.1 Users care and cultural appropriateness* To reinforce cultural values and the context of any design project, treating all groups with dignity and respect (e.g. the design is not stigmatizing on gender as in toilets, staff and users' spaces, personnel available and trained to support people with disabilities etc.). *3.2.2 Social relation* To encourage active participation for individuals to the activities with others or privacy promotion (e.g. gathering spaces organization, furniture arrangement, visual privacy from the clinic suit, etc.). *3.2.3 Design process* To involve in the design process different stakeholders (users, experts, client, etc.) as a support, in order to understand their needs and ideas fostering their achievement in the design practice.

current research to reach a Universal Design project, which addresses the intersection of human performance (anthropometry–biomechanics and perception-cognition) and social participation.

The 8 criteria are the objectives that needs to be evaluated. Criteria branches off by the categories, highlighting conceptual levels on which to act in order to reach an in-depth understanding about Universal Design, in relation to healthcare structures. The framework adopts indicators that specify the objective and summarize concepts from each criterion establishing a link from the theoretical sphere to the concrete one. Finally, the requirements are references able to evaluate the defined objective. In particular, they represent the performance-based strategies that the project should reach as goals.

Categories, criteria and indicators are based on literature, workshops, and hospital case studies analysis. Their descriptions derived from knowledge assemble from references of both the UD/DfA criteria sets and assessment tools and design guidelines manuals. Table 1 shows the framework with the descriptions of each category and criterion and the aims of each indicator.

Requirements

The requirements are practical and measurable standards as possible solutions that the project has to achieve. Each indicator is composed by one or more requirements to measure or verify the presence or the absence of a feature with a binary scale. Table 2 shows the number of requirements for each environment. The requirements of the tool have been selected by both evidence-based references of existing tools and guidelines emerged from the literature review and by evidence of the hospital case studies analyzed through the empirical study.

Evaluation system

The evaluation system includes mandatory requirements to be achieved (pre-requisites) in order to verify that the minimum requirement of accessibility regulations is met, below which a building cannot be defined as accessible. The remaining indicators assess quality, verifying the level of inclusion with a performance-based approach.

The Universal Design quality assessment is the result of the fulfilment of the requirements defined for each environment of Table 2. Requirements are assessed through a binary scale (presence/absence) where the value of each of the indicators derive from the presence or absence of various requirements (Yes, No, N/A) as showed in Table 3. The formula for each score calculation and the weight system are described in detail within the doctoral research (19).

The building obtains an overall score through a letter corresponding to six different result ranges (Figure 4), using a similar approach to energy

Table 2. Number of requirements of Design for All A.U.D.I.T. tool.

Building Environment	N° of Requirements
Outdoor spaces	53
Entrance	60
Horizontal circulation	47
Vertical circulation	21
Waiting rooms	41
Bathrooms	30
Food service and vending	22
Offices and meeting rooms	33
Outpatient department	47
Inpatient department	102
Overall Service	61
Total requirements	517

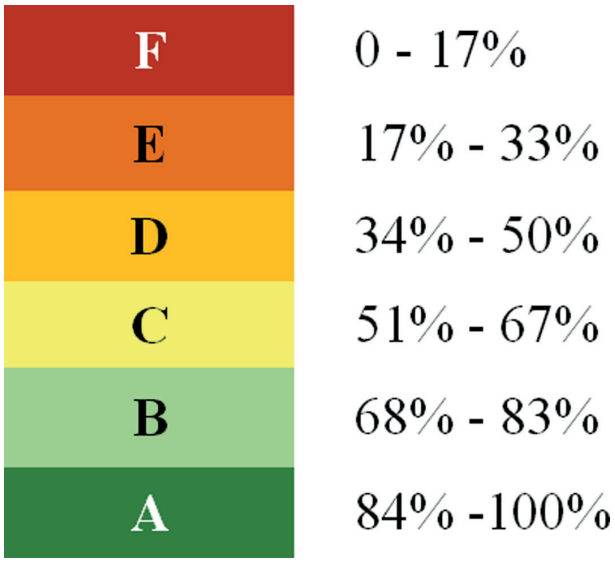

Figure 4. Results range.

Table 3. Extraction of the tool "Entrance" section.

Category	Criteria	Indicator	Requirements	Value
Sensory and Cognitive quality	Wayfinding	Visual and perceptible information	Wayfinding system includes visual and tactile and/ or audible directional signs at all primary entrances, indicating the location of primary destinations.	YES
			Wayfinding system uses color coding to refer to the main areas of the building and to different departments or floors.	YES
			There are maps or models at all primary entrances, indicating the location of primary destinations.	NO

assessments and the UDBRI tool (29), which proposes a graphical representation of the results on the floor plan.

The evaluation is flexible, since it depends by the level of accuracy required. The tool can provide a detailed evaluation, configuring the number of environments to be evaluated (e.g. outpatient clinic floor 1 or outpatient clinic floor 2), or it can provide an overall picture of the building quality by evaluating a fixed number of environment (Table 4).

Evaluation report

The results of the evaluation are provided in reports with both quantitative and qualitative information, with an overview of the main building performance scores achieved.

As a result of the evaluation, Design for All A.U.D.I.T. provides:

- reports with diagrams showing the evaluation scores for each environment of the hospital according to the different Universal Design categories, criteria and indicators. The evaluation report provides a direct understanding of the critical areas;
- space plans (heat maps) to highlight the performance of each environment. The heat map allows to identify the most problematic areas of the assessed facilities and gives an immediate representation of the associated criticalities in terms of accessibility;
- design strategies for improvement related to the criticalities detected.

Table 4. Scores about the different criteria and related areas of the tool test.

ENVIRONMENTS							
CRITERIA	**Outdoor**	**Entrance**	**Circulation spaces**	**Support spaces**	**Overall Service**	**Total Criteria**	**Values**
Usability	57%	88%	72%	85%	100%	**80%**	**B**
Functionality	100%	100%	100%	42%	50%	**78%**	**B**
Safety & Security	25%	83%	70%	50%	88%	**63%**	**C**
Wayfinding	45%	29%	45%	38%		**39%**	**D**
Understanding	100%	63%	75%	25%	57%	**64%**	**C**
Environmental Factors	100%	75%	100%	83%	88%	**89%**	**A**
Well-being	45%	100%	50%	100%	83%	**76%**	**B**
Social Inclusion	70%	100%	100%	71%	92%	**87%**	**A**

Design for All A.U.D.I.T. therefore enables health facility managers (and facility managers more generally) to understand the priorities for intervention in decision-making processes aimed at increasing the well-being and satisfaction of their customers as well as the social impact.

Discussion and conclusions

Design for All A.U.D.I.T. is a tool that evaluates the quality of building according to Universal Design through a new set of objective and performance indicators with an evidence-based approach. The research explores the user-friendly tool to assess and monitor the quality and criticality of spaces in existing buildings by generating benchmarks of the level of inclusion. It offers effective decision support to designers and decision-makers with specific strategies for both new projects and renovations to develop inclusive hospital regardless of users' abilities or disabilities.

The study demonstrates through MCDA methodology, that it is possible to evaluate UD criteria through a reliable framework of assessment. Nowadays different guidelines and standards provide requirements on DfA and UD (e.g. EN17210:2021) to support the building industry professionals to design accessible and inclusive built environments, in addition Design for All A.U.D.I.T. provides a method to evaluate the quality of the environments by means of performance-based requirements.

The tool has been applied in hospitals, but the structure of the system is flexible and was already applied in different typologies of buildings as schools and libraries. Indeed, the aim is to develop the first quality certification of buildings based on UD and DfA criteria and principles.

The structure of the tool allows a transversal evaluation, because for each environment of the hospital, are available data on Physical, sensory-cognitive and social quality. The criteria of the framework represent UD goals and outcomes on people well-being that can be monitored for each space. Reports can provide targeted design strategies related to a criterion (e.g. wayfinding) or in relation to an area of a building (e.g. the entrance).

Indeed, most of the existing DfA and UD assessment tools and accessibility regulations are building-centric, as they provide judgments on different areas concerning just the overall picture of UD quality (e.g. EN 17210:2021 and UDIBRI by O. Shea (29)). Conversely, the tool provides feedback about DfA categories, criteria and indicators, analyzing for example usability, orientation or inclusion in relation to different areas of the building. On the other hand, most of the existing building rating systems on sustainability and wellbeing (e.g. LEED, WELL or BREAM) evaluates different aspects of the overall building, while the tool provides information also on specific areas, since as defined by UD evaluation theories, the needs of users are different in respect to the circumstance.

The only systems revealed by the analysis that evaluate UD spaces' performance are is UD Certification by IDeA Centre (Buffalo, NY) (15) and Clear Code Architecture by PMMT Architecture (30), but these do not relate the requirements to a framework of UD Principles, but only to the various areas of the building (Clear Code Architecture to different types of users).

Limitations and future challenges

The limitations of the study are the number of applications; however the aim is to engage different hospitals to apply the proposed evaluation tool, in order to continue the process of validation and test.

In addition, the study does not provide a self-evaluation by the client, however this can produce bias in the analysis of the data. In relation to times, the on-site audit requires a period for the analysis that maybe some decision-makers do not appreciate, however this is faster than the use of a Survey, which is more time expensive and has a subjective approach.

Future research can be done testing in existing buildings before and after renovation through the application of the tool. This will allow to collect data on evidence about UD design solutions and their influence on people's well-being. The authors are in the process to seek a copyright of the tool for intellectual property preservation and they are addressing applications on different facilities and with various stakeholders. For long term research when the tool will be able to be used for any building typology (e.g. sport, office, schools, etc.), it will be possible to scale up the tool to larger community contexts. In addition, the structure of the tool could also be adopted by public administrations to evaluate projects inclusion and usability quality over the legislation on accessibility.

The tool could be integrated to Building Information Modeling (BIM), indeed the tool's requirements can be included as standards to automatically evaluate the design or to monitor the existing building situation. Finally, the use of "smart" technologies can be used to shift from an evaluation that needs to be performed partially on site, to a digital evaluation. For instance, sensor systems in buildings can track performance in multiple dimensions, e.g. illumination, acoustics, thermal performance, etc.

To conclude the study proposes a tool that can increase the well-being and satisfaction of the facilities' users.

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