Designing Hospitals Through the Lens of Universal Design. An Evaluation Tool to Enhance Inclusive Healthcare Facilities

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Abstract. Various studies highlight a gap on reliable methods to measure the quality of projects and environments in terms of Universal Design (UD) and Design for All (DfA). In particular, healthcare facilities need decision support systems to improve the well-being of as many users as possible through a systematic approach. The present research proposes an evaluation tool to support designers and decision makers in the adoption of UD to develop healthcare facilities suitable for a wide range of users. Several methodologies have been adopted: an in-depth literature review on the current state of knowledge on UD evaluation, workshops and focus groups with both users and experts, and the analysis of four hospital case studies. The result was an evaluation framework built by using a Multi-criteria Analysis (MCA) methodology. The first version of the tool was applied to an American hospital and validated d in an Italian pilot case study. The research outlines a tool called *Design for All A.U.D.I.T.*, able to evaluate Physical, Sensory-cognitive, and Social qualities based on a hierarchical framework with criteria and indicators based on UD and DfA. The framework evaluates the different areas of the hospital from outdoor to indoor spaces, allowing hospital administrators to act to improve the well-being of users according to the critical aspects of UD identified by the tool. The analysis provides a report of the facility status and design strategies to support designers for new projects or buildings renovations. The application shows that *DfA A.U.D.I.T.* can assess hospitals by examining both spatial qualities and DfA criteria. The tool could represent a decision support system in the national and international context, where many hospitals are not newly built. Further research will include application in different facilities and building typologies, aided by the flexible structure of the tool, which allows measurement of the environment's quality in terms of DfA and UD.

Keywords. Inclusive Design; Design for All; Evaluation; Hospital; building performance assessment

1. Introduction

More than 25% of the European population faces accessibility problems every day in both indoor and outdoor spaces. The issue is crucial, especially in hospitals, which are

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used by people with varied needs and health statuses. The design of healthcare facilities is gradually placing people at the center to meet the needs of many users, without being limited to purely functional aspects. Therefore, research focuses on the hospital environment as a complex social structure, because of the plurality of functions and users (e.g. patients, visitors, workers) with varied needs and impairments [1]. In the hospital environment, aspects such as accessibility, orientation, and comfort, too often report criticalities and disabling situations, with a negative impact on the well-being of people, which compromise the performance of the entire service [2]. However, if users' needs are considered early in the design process, they can be integrated into interventions, limiting the cost of later modifications [3].

Awareness of the benefits of an inclusive environment on all people is growing, to allow everyone to take part in social activities with the same quality of experience, ensuring the dignity of all users [4]. Different approaches to universal design (UD) exist in relation to the geographical context where they have been introduced. UD was developed in the United States [5] followed by the Principles of UD to guide professionals in the application of UD (Connel). *Design for All* (DfA) was defined in Europe in 2004 as "*the design for human diversity, social inclusion and equality*" [6]. All of the theoretical approaches have the common objective to "enable and empower a diverse population by improving human performance, health and wellness, and social participation" [7]. This paper uses the term *UD* to describe all of the aforementioned design philosophies.

Even if the effectiveness of UD is proved on people's well-being [8], there is no official and scientific agreed upon methods to support the design of inclusive environments in a practical way, neither to evaluate objectively how UD is applied or what outcomes are achieved [9-10]. Sustainability assessment protocols for post-occupancy evaluation (e.g. LEED, BREAM, WELL) perform an assessment with objective indicators; however, they only consider legal accessibility standards or a single UD indicator in the whole protocol.

Systematic and scientific approaches that support the translation of inclusive strategies into design practice are still used in few studies [10]. They would make the benefits that UD has on a wide range of people with diverse needs tangible [11]. It is therefore necessary to introduce a performance-based approach that can assess the quality of usability and inclusion of environments by means of measurable and objective criteria in order to support designers and decision-makers on issues of such complexity [12]. In particular, this is crucial in healthcare facilities, to integrate human factors in the design process and provide a real impact of inclusive design on people's well-being [13].

The present study proposes an evaluation tool to support designers in the adoption of UD to develop healthcare facilities suitable for a wider range of users [14]. To date, there are no systems in Europe to assess and certify the inclusion of a building or an environment. The tool allows an objective and performance-based evaluation of the quality of hospitals according to UD and DfA strategies [15].

2. Objectives and Research Questions

The objective of the research is the development of a tool aimed at supporting decision-makers in the hospital environment to enable the design of inclusive environments according to UD goals by evaluating the quality of the environments in an objective and performance-based way. To date, in Europe, there are no systematic evaluation methods

to certify UD and measure the impacts of inclusive design. The developed tool assesses physical, sensory-cognitive and social quality, focusing on the needs of people, from staff to patients and visitors, ensuring a support system for decision-makers and designers. The research aims to bridge the gap between theory and practice in UD, showing the tangible aspects of UD through indicators that allow users to define its quality. In this regard, the main research questions address the following issues:

- RQ1: How is it possible to measure the quality of a project in terms of UD, assessing the usability of environments and social inclusion through a performance approach to generate objective and evidence-based data?
- RQ2: How is it possible to measure the usability and inclusion in hospital environments and projects to improve the well-being of diverse users?
- RQ3: What is the best way to evaluate these factors to support decision-making for both new projects and existing buildings?

3. Method

The research methodology is set up according to three different phases that define a process: (1) Analysis: State-of-the-art; (2) Elaboration: Research and definition of the tool; (3) Application and validation: Case studies. The research is based on an interdisciplinary approach, since the tool is the result of a plurality of methods involving both theoretical and empirical analysis.

3.1. Analysis phase

This phase provides an overview of UD and DfA strategies in the national and international context, with references to the related legislation framework. A systematic literature review addresses the relationship between UD/DfA and evaluation [12]. Through *Scopus* and *Web of Science* databases, more than 1,700 scientific contributions emerged. Of the 21 most relevant, the existing evaluation theories, criteria, methods, and tools on DfA/UD are analyzed. Finally, an analysis of DfA in relation to healthcare environments is performed, from which current gaps emerge, including that there are no specific tools for the hospital environment.

3.2. Elaboration phase

This phase describes the development of the tool. The UD assessment framework is generated from data collected through the analysis of results obtained from the literature review; with the analysis of four existing hospital settings; and direct involvement of stakeholders (experts and users with and without disabilities) through six workshops aimed at understanding the objectives behind an inclusive project [16]. Data were gathered following a Multi-criteria Analysis (MCA) methodology [17] to adopt a reliable approach to compare qualitative and quantitative data of the same project. The framework was then reviewed through interviews with national and international experts to gather data on the characteristics of UD in health care settings.

3.3. Application-validation phase

This phase involves testing the tool on two existing private hospitals as pilot case studies to test the reliability of the assessment system. The first version of the methodological tool was applied to a hospital in Buffalo (NY), to test the usability of the method in an international context. This study allowed for revision of the structure of the tool along with a focus group with experts. In addition, a questionnaire was developed with expert support and applied to the hospital. The questionnaire was used to compare the objective analysis of the tool in relation to the users' experience (staff and visitors) within the same hospital. The study confirmed the validity of the evaluation instrument by comparing its requirements and categories with the items of the questionnaire. A second version of the tool was validated at a hospital in Milan (Italy), highlighting the strengths and weaknesses of the new version.

4. Results

The study explored the evaluation of UD quality in relation to the hospital environment to improve the use of spaces and social inclusion for all different individuals, going beyond the minimum accessibility requirements for specific categories of users. This research fills the gap identified by the extensive literature review: a lack of DfA or UD assessment and support tools that can measure performance through a scientific and systematic approach (RQ1). Especially in the context of healthcare facilities as complex constructs, methods for prioritizing interventions are needed to support decision-makers in managing the complexity of user needs.

Table 1. *Design for All A.U.D.I.T.* evaluation framework.

Categories	Criteria	Indicators
1. Physical quality	1.1 Usability	Comfort in using spaces Comfort in using furniture
	1.2 Functionality	Flexibility Distribution
	1.3 Safety & Security	Minimize risk situations Safety and security perception
2. Sensory/cognitive quality	2.1 Wayfinding	Orientation through the layout Visual and perceptible information
	2.2 Understanding	Information is easy to understand Communication and info awareness
	2.3 Environmental Factors	Light Acoustic Thermal comfort Air quality
3. Social quality	3.1 Well-being	Healing environment Health promotion and physical activity Hygienic conditions and maintenance
	3.2 Social inclusion	Users care and cultural appropriateness Social relation Design process

The research develops the *Design for All A.U.D.I.T.* (Assessment Usable Design & Inclusion Tool) [14], a UD performance assessment tool, capable of evaluating both hospital projects (decision support system) and existing buildings (post-occupancy

evaluation) (RQ2). The structure of the tool is based on sections related to the various areas of the buildings and the proprietary UD assessment framework is related to each of them (Table 1). The spaces that represent the various sections are: outdoor spaces, entrance, internal circulation, support spaces, core spaces, and general service.

For each section, the evaluation adopts a performance-based evaluation framework (Table 1) developed in the study through MCA (phase 2). The framework is composed of a hierarchical structure able to evaluate three DfA/UD outcomes: physical quality; sensory-cognitive quality and social quality; eight criteria; 20 indicators; and nearly 500 requirements derived from the literature and case studies [12] to compare quantitative and qualitative aspects of the same project. The tool's requirements represent the performance design strategies that the project should reach as goals. The UD quality assessment is the result of meeting the requirements defined for each environment through a binary and weighted system The tool is based on a performance approach through goals to be achieved, in a process of dialogue with designers and decision makers.

The diagram (Figure 1) shows the overall assessment of the 'Entrance' area carried out during one application in a hospital. The score for each of the indicators is derived from the presence or absence of various requirements (building's features).
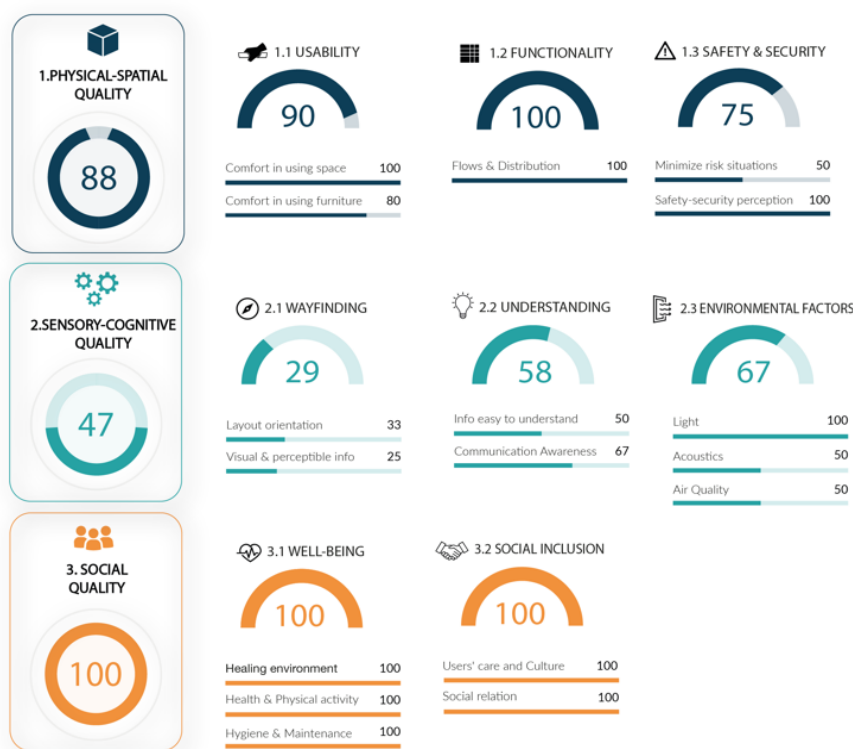

Figure 1. Outcome of one hospital pilot case study assessment through the *Design for All A.U.D.I.T.*

This hierarchical structure allows the tool to be easily implemented and updated over time by modifying the indicators and requirements related to new evidence. In addition, the framework is composed of a flexible criteria and indicators (C&I) structure for all building types, applied and developed in this study for the hospital environment.

The proposed evaluation method is based on a performance approach, providing architects with targets to achieve related to user needs, overcoming the performance approach of current accessibility legislation. The framework clearly defines the relationship between UD goals and outcomes on people's well-being.

With respect to the comparison between UD and DfA evaluation, this research sets the stage for a relationship between the American and European scientific scenarios on these fields, to support the improvement of the inclusive environment for a wider range of users. The tool is based on the UD approach that the Goals of UD [7] promote: an evaluation using objective and performance indicators.

On the other hand, the few accessibility and inclusion assessment tools that have been developed in the last twenty years are based on checklists that provide only percentage values with respect to the quality of various environments. *DfA A.U.D.I.T.*, intercepts from the European DfA strategy, the need to consider each project in a specific context and provide the designer or decision maker with descriptive knowledge [18]. The requirements, which in existing tools are simply divided by areas of the building, in *DfA A.U.D.I.T.* are organized through the DfA framework, which allows users to understand the specific characteristics and the real impact of UD/DfA strategies. For example, it is possible to assess the 'Wayfinding' or 'Security' criteria in relation to the entrance, and not just the entrance area in a general way.

Finally, the tool is able to provide the following different feedback: graphs that directly show the percentage of quality achieved with respect to each space of the building and the different UD/DfA criteria; floor plans analysis; reports with qualitative and quantitative information on the evaluation, which include different levels of detail related to areas of the hospital or UD features (RQ3).

4.1. Findings from the tool application

In both pilot case studies, hospital administrators and designers familiar with the project were involved during the evaluation process and data review prior to completion of the study. It was demonstrated how the tool can be incorporated into a post-occupancy evaluation analysis to provide objective data, combined with other methods, such as interviews, focus groups, and questionnaires, which were conducted in the first pilot case to obtain feedback from users.

The applications demonstrated that *DfA A.U.D.I.T.* can assess hospitals by examining both spatial qualities and DfA criteria. For spaces, 'horizontal circulation' had the best scores in both hospitals (76% Italian, 88% US). Regarding DfA/UD principles, the lowest score was 'social inclusion' (87%) in the Italian hospital and 'wayfinding' the lowest in the American one (39%).

In addition to the percentage, the evaluation can also be graphically represented in plan, with colors assigned by the evaluation representing the judgments (Figure 2). In this way, the evaluation report provides a direct understanding of the critical areas using a six-color rating scale. The same analysis can be completed at the level of categories, criteria and indicators for each area.

The assessment can be used to compare different case studies or to give suggestions on how to improve the building periodically thanks to the indicators. The outcome of the assessment, in the case of existing buildings, highlights the criticalities in the DfA/UD characteristics and provides design strategies for improvement, while in projects, it provides best practices to be followed with respect to aspects not yet considered. In addition to assessing the quality of spaces, the tool aims to provide decision support to

identify priorities for intervention. The tool is intended to be used to support decision makers, designers, and managers of facilities, from the beginning of the design process, focusing on the needs of people.
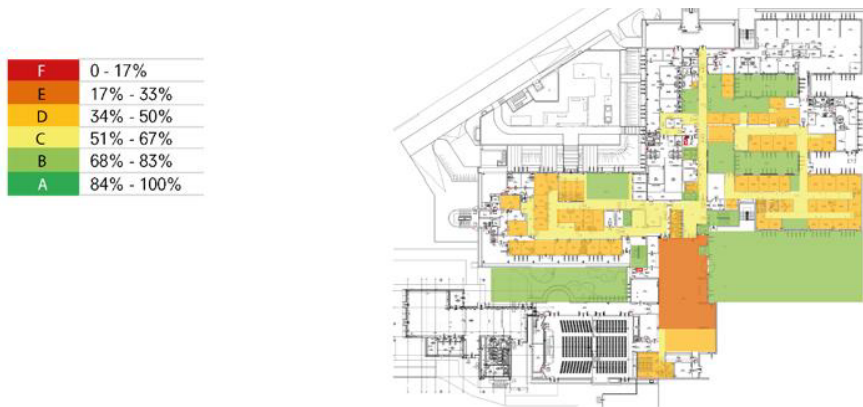

F	0 - 17%
E	17% - 33%
D	34% - 50%
C	51% - 67%
B	68% - 83%
A	84% - 100%

Figure 2. Graphical representation of the color-based evaluation of the Italian pilot case study.

Through the adoption of MCA, it demonstrates it is possible to measure DfA quality through an objective evaluation process and compare quantitative and qualitative aspects of the same project.

5. Conclusions

A method to improve inclusion in healthcare facilities has been developed, adopting both DfA and UD strategies in a rating system that evaluates buildings' performance. On the one hand, the study demonstrates that UD strategies can be applied in hospital design to improve accessibility and well-being for all users. On the other, the evaluation of hospital buildings highlights the importance of discovering the impact of the built environment on user well-being and making the benefits of UD measurable.

Currently, the tool is being applied in a larger sample of hospitals and healthcare facilities, to continue the validation process. The research has only tested the tool on existing hospitals, but there are plans to apply it in new projects as well. In this regard, a comparative study could be carried out between the performance of a new hospital designed (following the assessment proposed by *DfA A.U.D.I.T.)* and a hospital that does not consider the DfA assessment to collect evidence-based data, demonstrating influence of DfA on people's well-being.

The tool could represent a decision support system in the European context, where many hospitals are not newly built, and have problems with accessibility, wayfinding, user comfort, and inclusiveness, which compromise the overall service. In addition, *DfA A.U.D.I.T.* could also be used for the design of new Italian local healthcare facilities to support the main hospitals called "*Case di Comunità*" and "*Ospedali di Comunità*".
The proposed DfA evaluation framework is flexible for other types of public buildings (e.g. offices, restaurants, schools, etc.) by modifying some requirements and indicators, as a system for a UD validation. In particular, in the Italian context the Italian Recovery Fund P.N.R.R. has allocated several resources for the promotion of Social Inclusion (mission 5). The research could then not only support making cities more accessible, but

also more inclusive for different users. In addition, the flexibility of the tool would allow its use by public administrations to assess the inclusion of projects and the quality of space usage in terms of accessibility. In Italy, the evaluation of the accessibility of public buildings is mandatory for each city with P.E.B.A. (*Piani di Eliminazione delle Barriere Architettoniche*) prescription. *DfA A.U.D.I.T.* could propose a systematized and innovative evaluation process to support public administrations, which would also favor the involvement of citizens as an active part of the process.

Overall, the research aimed to bridge the gap between theory and practice on DfA evaluation and to support the design of inclusive hospitals to improve the well-being of as many users as possible.

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