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LIVING LAB, AN INNOVATIVE APPROACH IN HEALTHCARE

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Abstract—Nowadays, healthcare systems are facing major challenges. Demographic and disease changes are causing an increasing healthcare demand. Moreover, healthcare systems have to consider financial realities, i.e. limited resources, cost reduction and new values based models. Citizens are more aware and informed and we are witnessing to an increase of their expectations in term of healthcare. They want to participate in the decision processes that regard their health. They also ask for a real-time support and an online access to their information. On this basis, new regulations and reforms are needed. In particular, investments are needed to prevent future costs provoked by an increasing demand of hospitalizations. The healthcare delivery has also to be rethought. In this paper, we try to highlight how the concepts of design thinking, participatory design and living lab can help to face these challenges in the healthcare field.

Keywords—design thinking, participatory design, living lab, healthcare, aging.

I. INTRODUCTION

Today's society appears particularly dynamic and rapidly changing. Industries need instruments capable of identifying and interpreting scenarios in continuous evolution, evaluating new applications and managing the technological innovation. This is particularly flagrant in healthcare, where there are mounting cost pressures together with a growing expecta- tion by citizens about service quality. Key points for cost reduction and improvement of patients experience are op- erating efficiency, interoperability and the development of new models for the interaction with patients. Indeed, often, patients are considered only as recipients of cares. Usually, they don't play any role in the decision processes concerning the provision of medical treat- ments. Such role is exclusively a matter for healthcare professionals. Also for what concerns the technology to support healthcare, users are rarely be considered. Consequences of this approach is the little use of services and digital technologies in healthcare. This fact causes little-known and little-used services. Moreover, since these services are designed without taking into account opinions and considerations of consumers, they often results in undesirable products, mainly for the unpleasantness and the low user- friendliness.

Health should have as reference point the needs of peo- ple and not the technological and market push. In order to overcome this problem, methodologies such as design thinking [1] and participatory design [2] are rapidly spreading. Such concepts are strictly connected with the empowerment of patients and care-givers [3]. Such new instruments enable to adapt, personalize or even realize more effective solutions. Industries can benefit from these new approaches for the design of products and services to satisfy explicit or not yet defined needs of consumers.

II. DESIGN THINKING

Design thinking (Fig. 1) is a problem solving methodology that uses creativity and innovation as key elements. It takes in consideration the needs and the context of use of services. It is a methodology that includes a series of cycles and places great emphasis on "Empathy" as a way of understanding consumers and their behavior.

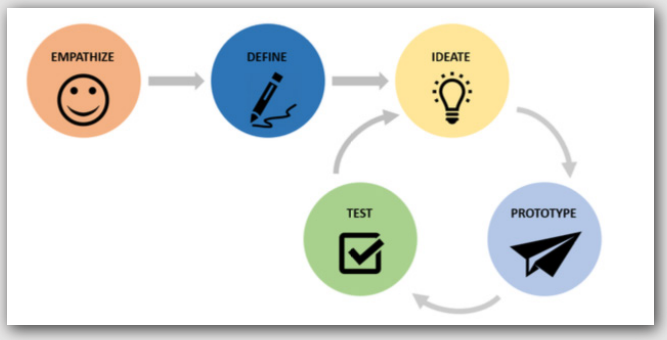

Fig. 1: The design thinking methodology.

Usually, the first phase consists in an empathic understand- ing of the problem. During this phase, it is important to empathize with interested people to understand their experi- ences and motivations. It is crucial to obtain the best possible understanding of the actual users' needs and the problems that underlie the development of the service or product. The second phase redefines and focuses the problem on the insights coming from the first phase. In this phase, an analysis of the previous observations is carried on in order to synthesize them. The aim of this phase is to define the core problems in a human-centred philosophy. This allows to overcome any barrier and resistance on the part of recipients of the service or product. The third phase consists in develop creative solu- tions. Several techniques could be used, such as Brainstorm, Brainwrite, Worst Possible Idea, and SCAMPER [4], [5]. All proceeds in a way that is shared and collaborative, taking always in consideration the actual context. Already at this stage, the most interesting ideas shall be tested to verify their feasibility and competitive benefits. The fourth phase concerns the construction of prototypes. The aim of this phase is to understand which components of the proposed solutions work and which do not. In the last phase, designers test the effectiveness of the best solution, identified during the prototyping phase.

Through this crucial phase it is possible to delete completely any kind of problem before the development itself. It is important to underline that the design thinking methodology is an iterative process: for example, often the results generated during the testing phase are used to elaborate new solutions that require the development of new prototype and of a new testing phase.

Thanks to this methodology, it is possible to include from the beginning all the stakeholders that are interested in the service itself. This creates a multidisciplinary perspective of the development of the service that can only enhance it. The design starts from the actual context of use of the services for citizens. This fact allows to overcome a purely technical mentality. Indeed, innovation is not about technology, but about the use of the technology by people. Moreover, the design thinking allows to bring closer the services to the real need of the users. A mean of dialogue is created between the technical perspective and the social perspective. The result is a better service.

III. PARTICIPATORY DESIGN

Through the 1980s, the user-centered design (UCD) [6] emerged as a new approach that profoundly changed the way interfaces, and eventually all systems in general, are designed. In UCD, "development proceeds with the user as the center of focus", i.e. the user is the center of the whole development process.

Putting the user with his/her needs, desires and limitations at the center of the design process determined the end of a blind technology-driven progress. This was also reflected in the development process evolution. Indeed, at the beginning systems were developed following the "Waterfall" approach, which consisted of sequential phases (Fig. 2). The first step was the collection of information about the system that should be developed, which included interviews to the users; then requirements were formalized from these data and processed to provide the design. Usually, the design determined in the second phase of the process was definitive for the rest of the development and tests were performed at the end to evaluate the product.

The UCD completely changed the system development process, which became iterative: every phase is now performed involving the user many times. The analysis, design and development are performed rapidly in order to provide first prototypes to test with users in order to understand what is appreciated and what can be improved. Then, the whole process is performed again and again to converge towards the optimal solution. Involving the user in the system development process al- lowed to better respond to user's needs and desires; moreover, it became an opportunity for innovation.

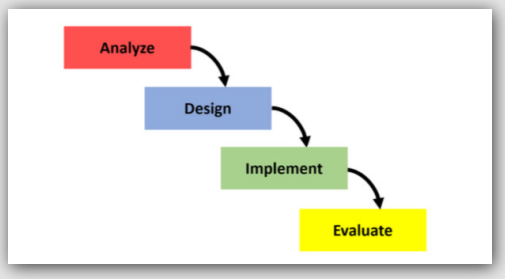

Fig. 2: The "waterfall model". Progress flows from the top to the bottom, like a cascading waterfall.

The success of this approach made clear that the involvement of the user is crucial for the design of systems and this led to the rise of a new trend where user participation is even more important, which is called co-design [7] (also known as participatory design). In this approach, the user changes his/her role from passive object of study (as in UCD) to co-designer (Fig. 4). In UCD, the researcher observes and interviews the user to bring knowledge to the designer. In the co-designing process, the researcher, designer and user work together to design the new system (Fig. 4b).

In this case, the user plays a large role in knowledge development, idea generation and concept development becoming a co-author of the future system.

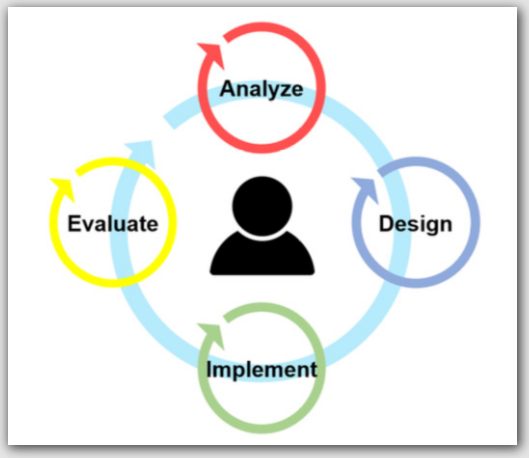

Fig. 3: The user-centered design model. An iterative design process in which designers focus on the users and their needs in each phase of the design process.

Such design methodology is particularly well-received be- cause it contrasts the current trend of the isolation of the urban areas. Moreover, it allows to take in consideration the plurality of current interest in a territory and the contrasts surrounding processes of change. Participatory design allows reaching a more profound un- derstanding of the user's needs and desires. In fact, UCD was focused on what the user said and did while the researcher was interviewing and observing him. Participatory design focuses on what people make in order to explore also what users feel, know and dream. This brings to access what is called the "implicit knowledge" of the users, which could not usually emerge during interviews.

This deeper understanding of the users allows designing sys- tems that can better match users' needs increasing users' satis- faction; it enables inclusive design by involving the typologies of users that are usually design-excluded; it can offer an opportunity to raise awareness and for education; in particular, in the healthcare domain, empowering the users both during the design process and in the health self-monitoring allows achieving more effective services and ensuring sustainability of programs.

Participatory design is particularly important in smart cities because it allows for open innovation.

Participatory design is linked with the new direction aimed at rebuilding a new social deal in which public administrators (the decision-makers), technicians (the designers), and citizens (the recipients) shoulder together the challenges that affect the community. The aim is to overcome the traditional purely welfare directions that are centered only on offers related to solutions, which are handed down from on high. This will reduce the delegation of power to the institutions, increasing the citizens' initiative and responsibility.

(a) Classical roles of users, researchers, and designers in the design process.

(b) The co-designing process

Fig. 4: Traditional and co-designing process comparison [7].

IV. THE LIVING LAB CONCEPT

Performing participatory design for smart cities requires an organization and specific infrastructures; these are usually under the form of "living labs" [8]. The living lab concept was first introduced by Prof William Mitchell at the MIT Media Lab [9], [10]. A "living lab" is an open innovation ecosystem frequently operating in a territorial context aiming at engaging competence clusters, local authorities and citizens within social innovation environments. The main objectives consist in fostering co-creation among these three actors to explore new ideas and concepts, experiment new artifacts and evaluate breakthrough scenarios to promote innovation. As explained in [11], [12], common elements of a living lab are (Fig. 5):

• Multi-method approaches: there is not a single living lab methodology. All living labs combine and customize different methodologies to best fit their purpose;
• User-engagement: the users are involved at the beginning of the process and this is the key of success;
• Multi-stakeholder participation: even if the focus is on users, involving all relevant stakeholders is of crucial importance. This includes representatives of public and private sectors, academia and people;
• Real-life settings: the very specific characteristic of living labs is that the activities take place in real-life settings to gain a truthful overview of the context;
• Co-creation: the users become equal contributors rather than subjects of study. They participate as co-creators in a co-design philosophy.

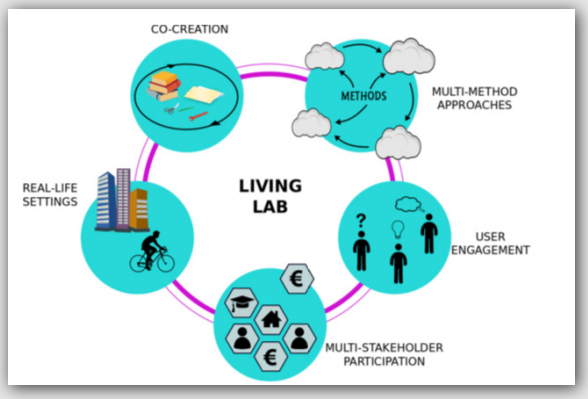

Fig. 5: Main components of a living lab [11].

There are three main building blocks within living lab projects follow the innovation and development phases [11]:

• **Exploration**: it is necessary to know the current state and design possible future states. Is is about moving from ideal towards concepts or prototype of the solution;
• **Experimentation**: the real-life testing of what was pro- posed. The concept is put to the test by developing and experimenting with the prototype;
• **Evaluation**: the assessment of the impact of the experiment with regard to the current state in order to iterate future states. The goal is to implement the innovation into the target market relying on a go-to-market strategy.

Living labs stimulate innovation. They transfer research from laboratories to a real-life environment. In such a context, citizens and users become themselves co-developers. They create, together with the designers, new products. Moreover, they define the specifications, assess the first prototypes and test the future technological solutions in the real quotidian world, e.g. in their homes.

In contrast to a traditional laboratory, a living lab operates in a real environment by placing the stakeholders at the heart of its activities. The physical and organizational boundaries are defined by purpose, scope and context. In particular, the same participants define the goals, the project duration, the involvement of actors, and the degree of participation. A living lab can take place on a street, in a house or within an organization. It can involve a whole city or industry. It depends on the project itself.

Methodologically, living labs are networks composed of ac- tors, resources and heterogeneous assets. These elements will supplement the research that focuses on the stakeholders and open innovation [13]. Living labs are structures enable testing and co-creation with the stakeholder in real-life scenarios.

Living labs are particularly useful in contexts where com- plex challenges must be faced. In real-life contexts, it is very difficult for a single actor to find the correct solution. Collaborating and co-creating the solutions with the final users and the involved actors, complexity and uncertainty drop down. Moreover, the possibility to find a sustainable solution increases.

An interesting example of the concept of living lab applied in the healthcare field can be found in AUSILIA (Assited Unit for Simulation Independent Living Activities) [14]. AUSILIA is a collaborative project involving the Local Health Trust (APSS) and a number of Engineering Department of the University of Trento, but open also to cooperation with private stakeholders, as health and care product and service devel- opers. AUSILIA is an innovative approach aimed to enable the personalization of care paradigm by identification of the best set of supportive technologies to help in recovery self- sufficiency and ensuring independent living at home.

AUSILIA has been realized at Villa Rosa hospital, an APSS premise located in Pergine Valsugana, Trento, Italy. Based on the strict collaboration of clinical and engineering professionals, it leverages on the availability of an apartment with a specifically designed home automation system, a re- configurable gym, and an engineering laboratory. The smart apartment and the gymnasium are equipped to monitoring patients daily life and testing of architectural, ergonomic and technological solutions. With a surface area of approximately 66m^2 , the apartment has one kitchen-living room, one bedroom and one bathroom. It has been partially refitted to satisfy the needs of persons with physical, sensory and cognitive difficulties while performing basic Activity of Daily Living (ADL) as for example toilet hygiene, bathing, showering, dressing, self-feeding, etc., and "instrumental" ADL (e.g. cooking, housekeeping, etc.). The aim is to allow the patient to live in the structure for a medium-short period (typically from 1 to 4 days) in a fully realistic environment where he/she can learn the use of a set of architectural solutions and assistive technologies potentially suited to his/her needs evaluating their use at home.

Located in a zone of approximately 372m^2 , the Gymnasium is a flexible space equipped with dedicated functional areas for the evaluation of the users abilities while performing ADL. The main parts are the bathroom area, the kitchen area, the door area, the handles area and the stairs area. They are equipped with elements of variable configuration. In addition, the gym is integrated with standardized items (e.g. ramps, slide slope, steps, and flooring area) for the evaluation of the mobility related skills of the user. The main function of trial gymnasium is to allow the assessment of patients abilities within ad hoc domestic spaces where different and re-configurable Ambient Assisted Living (AAL) technologies can be tested in order to find the best fitting configuration for their comfort.

The above described complementary setting aimed to help people who have experienced deterioration in their health and/or have increased support needs to relearn the skills re- quired to keep them safe and independent at home. Additional marked point of AUSILIA is the continuous technological updating to warrant state of the art and sustainable assistive solutions. Thus, the link with third parties involved in pro- duction and delivery of assistive devices and personal care services results crucial for the living lab.

The structures of the AUSILIA Living Lab have been designed to be modified and integrated over time in order to enhance the research activity on new issues and to meet the needs of a wider range of users. AUSILIA will encourage the study of new technologies and design solutions for the home. The collected data might also be used to develop new guidelines for the designers and to support new studies related to a possible upgrade of the current regulatory provision and standards on the accessible design.

Another example of the application of the concept of living lab in healthcare is the CAPTAIN (Coach Assistant via Projected and TAngible INterface) project [15] founded by the European Union.

CAPTAIN will develop a new technology designed to turn the home of older adults into an ubiquitous assistant. The system will make use of projected augmented reality and real-time 3D sensing technologies to monitor and "comprehend" the user and the indoor space in order to provide contextualized and personalized coaching and instructions. Solutions will be designed for non-invasive user and environmental sensing including emotional and behavioral recognition, indoor location and gait analysis, physical and cognitive training, progress monitoring. Exploiting this infor- mation CAPTAIN will develop behavioral and AI algorithms which will allow the system to provide personalized advice, guidance and follow-up for key age-related issues in daily life which impact person's ability to remain active and independent at their home. This will include risk avoidance, nutrition guidance, physical activity and cognitive training follow-up, guidance for lifestyle and social participation.

To achieve these objectives, CAPTAIN will foster a truly user-centered co-design philosophy based on constant involve- ment of older adults in the design, development, and testing stages.

V. CONCLUSIONS

In this paper, we presented how the concepts of design thinking, participatory design and living lab can be useful to foster innovative approaches to face the increasing demand in healthcare. The practical example of AUSILIA and CAPTAIN were described, in which the living lab paradigm represents a turning point for the actual challenge of aging society with increasing demand of care and needs of assistance to foster independent living of patients suffering from impair- ing conditions. The concepts introduced in this paper can contribute to the development of new strategies, assuring the best assistive and caring solutions for ensuring for as long as possible autonomy and independence for citizens who age with sustainable and quality services.

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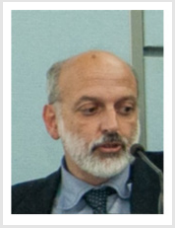

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