Smart Community-Based Services for Older Persons with Disability

A Desk Review and Analysis of Design Projects

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Abstract. Persons aging with disability (AWD) experienced the onset of disability in the early-mid life and their experience is quite different from those who acquire age-related disabilities in late life (disability with aging, DWA). Appropriate intervention models and services are required for these populations to enhance independent living and inclusion in a life-span and ecosystemic perspective. Smart Community-Based Services (SCBS) exploit technologies and systems to empower the persons into more integrated and coordinated networks. This study analyses the state of art in SCBS through a desk review. The 11 selected projects range from small to large-scale projects, adopt different approaches from techno-centric to user-centric, and exploit diverse key-enabling technologies to form smart ecosystems. Even if the research on this topic is still limited and often experimental, SCBS has the potential to address cross-population AWD/DWA needs, and connect diverse environments by orchestrating technologies, services and key-persons in the communities and favouring a more sustainable service planning.

Keywords: Aging with disability, Assistive Technology, Smart Community, Smart Community-Based Service, Service design, Desk research

1 Background

As a result of the social and medical progress, an increase in the life expectancy of persons with disabilities (PwD) has been registered [27]. *Persons ageing with disability* (AWD) are those who experience the onset of (motor, behavioural, sensory or intellectual) disability in the early or mid life and they grow old with disability [20]. Their experience is quite different from those who acquire age-related disabilities in late life due to the ageing decline (*disability with ageing*, DWA) [10]. AWD is subject to the interactive effects of age-related declines which tend to occur earlier and progress more rapidly compared to DWA. So, new needs for support with ageing-related challenges

are added to life-long needs for assistance [5]. This phenomenon calls for defining appropriate theoretical and intervention models for this specific population [4], redefining social-health services overcoming the assistive logic [21] while enhancing independent living and inclusion, addressing cross-population needs as well as working across service networks in line with a life-span and ecosystemic perspective [20]. In light of this, Smart Community-Based Services (SCBS) are designed to exploit technologies and systems (assistive and mainstream) connecting people, places and resources to empower ageing PwD, support the caregivers and promote new local opportunities. SCBS go beyond the design of stand-alone Assistive Technologies and aim at reorganising services into more integrated and coordinated networks using innovative technologies to pursue participation and inclusion for all as a common goal irrespective of age and abilities.

2 Objectives and Research Questions

This study maps the state of art in SCBS for adults and elderly with diverse forms of disability, analysing their design and technological implementation in real life contexts. The study is guided by the following Research Questions (RQs).

RQ1: What are the existing initiatives of SCBS for the ageing population?
RQ2: What are the approaches and the roles of the users in the design?
RQ3: What are the technological solutions, systems and services designed to respond to the needs of persons ageing with disabilities?
RQ4: What are the development trajectories for the future of SCBS?

3 Method

3.1 Data Selection

According to the RQs and their exploratory nature, a desk review was employed to investigate the state of the art and gain a broad understanding of the topic [9]. From October 2021 to February 2022, some databases were used to search for relevant case studies: IEEE Xplore, ACM Digital Library, Scopus, EU database of funded projects. The keywords used for the searching were: smart community*; service; disabil* older people OR disab* elderly; design, technol*; period: 2014 to 2022. The collected documentation includes scientific papers, book chapters and, when necessary, the websites of the projects were visited to collect further detailed information.

3.2 Inclusion/Exclusion Criteria

While most of the ATs are developed as single stand-alone solutions applied to specific life domains or activities (e.g, screen readers), we search for projects that integrate different tools, services, people and environments to create ecosystems tailored to the needs of persons AWD/DWA. The following inclusion criteria were used to select the

case studies: a) the document is in English language; b) the design project addresses people ageing with disability or disable elderly as target users; c) the design project proposes a SCBS as an ecosystem of technologies, users and contexts. This study does not consider theoretical contributions nor literature reviews, since it aims at investigating SCBS as they are designed and implemented in real contexts.

3.3 Data Analysis

Once collected, the desk review follows three steps [9]: 1) scanning the literature to keep focused on the research scope for the preliminary overview; 2) analysing secondary data, such as projects websites, to contribute to improving detailed information; 3) the team coordinator creates an annotated, linked list of all selected resources, organised by RQs.

4 Results and Discussion

The desk review contributes to identify n. 11 projects, whose main references, projects' name, year, countries and authors' background are listed in Table 1.

Table 1. List of selected projects

P01	Project title: **City4Age** [17]; *Countries*: Greece, United Kingdom, Spain, France, Italy, Singapore; *Authors' background:* Computer science, Engineering, Biomedical engineering; *Years*: 2015 - 2018
P02	Project title: **ACTIVAGE** [1] [17]; *Countries*: Spain, France, Italy, Germany, Greece, Finland, United Kingdom; *Authors' background:* Computer science, Engineering, Biomedical engineering; *Years*: 2017 - 2020
P03	Project title: **ProACT** [8] [15] [19]; *Countries*: Ireland, Belgium, Italy; *Authors' background:* Engineering, User Experience Design, Computer science, Economy, Psychology, Health Science; *Years*: 2016 - 2019
P04	Project title: **vINCI** [7] [28]; *Countries:* Cyprus, Romania; *Authors' background:* Computer science; *Years*: 2018 - 2021
P05	Project title: **Make and Connect** [23]; *Country*: Australia; *Authors' background*: Computer Science, Interaction design, HCI; *Years*: 2017 - 2019
P06	Project title: **My portfolio suite of apps** [23]; *Country*: Australia; *Authors' background*: Computer Science, Interaction design, Human-Computer Interaction; *Years*: 2016 - 2020
P07	Project title: **AYUDO** [26]; *Country*: Austria; *Authors' background*: Medical

	computer science, Software engineering, Graphic design, Applied psychology, Computer security; *Years*: 2019 - 2022
P08	Project title: **Contempo** [18]; *Country*: Indonesia; *Authors' background*: Computer science, Public Health; *Year*: 2014
P09	Project title: **Smart Home for the New Elder** [14]; *Country*: China; *Authors' background*: Industrial design, Service design; *Year*: 2020
P10	Project title: **Wearable Sensor Based Elderly Home Care System** [2]; *Country:* Bangladesh; *Authors' background*: Computer science, Engineering; *Year*: 2015
P11	Project title: **TCitySmartF** [11]; *Country*: United Kingdom; *Authors' background*: Computer science, Engineering; *Year*: 2019

The selected cases range from small projects (P04, P05, P06, P07, P08, P09, P10, P11) to large-scale projects (P01, P02, P03), with diverse objectives and methods, pointing out several design challenges. As emerged from the authors' backgrounds, the interdisciplinary nature of the projects is highlighted.

4.1 RQ1: Existing Initiatives of Smart Communities for Ageing Population

In most cases (P03, P04, P05, P06, P07, P08, P09, P10), the smart systems are designed for the home environment to monitor the person's health status (e.g., vital parameters, motility) and they are inspired by a biomedical model of well-being. Other projects highlight new trends (P05, P06) to support diverse life domains (e.g., socialisation, leisure activities) as a way to address hedonic needs and meaningful recreational activities which can positively impact cognitive functioning and mood [12].

These initiatives support the creation of a "community" as long as they involve the elderly and their caregivers, health-care and social services, all connected through smart objects, cloud infrastructures and mobile devices. Instead of merely supporting surveillance purposes, such ecosystems have the potential to meet the needs of the older persons for agency, empowerment and self-care [26], to continue living at home and prevent the hospitalisation, while supporting the work of the caregivers and limiting the pressure on the healthcare system [3]. Moreover, there is the need to expand the focus beyond the home setting towards the wider living environment, taking advantage of what the cities and the local communities already offer (P01, P02).

Finally, as highlighted by the literature [3], these experiences unfortunately share the limit of assuming experimental characteristics which would require stabilisation, generalisation, and a wider diffusion.

4.2 RQ2: Design Approaches and Roles of the Users

The selected case studies adopt different approaches along a continuum from a techno-centric approach focusing on the functional performance of the system (e.g., P8, P10), to a user-centric approach focusing on the user-technology interaction in real contexts (e.g., P3). The shifts between the opposite points along this continuum are needed in diverse design phases (e.g., definition of requirements, development phase) and a proper balance is pivotal to ensure that the designer's mental model fits with the users' mental models. Consequently, diverse levels of user involvement are required [6]: informative role when the users act as providers of information and as objects of investigation, consultative role when they comment and evaluate predefined design solutions (P01, P02, P08, P10), or participative role when they actively take part in the decision making process about the project solutions (P03). The remaining n.6 projects do not mention particular details about users' involvement.

It is acknowledged that the co-design with the target users drives to high quality solutions that really meet users' needs [22] and promote their abilities and desires [3]. But involving people with disabilities in the design process requires specific methods especially in the case of people with severe intellectual disability [16] [24]. Moreover, to design a SCBS, the involvement of diverse actors (e.g., informal caregivers, healthcare professionals) is useful to map the different needs [8] [15] [17], adopt a systemic perspective on the social and organisational factors which play a role in the promotion of well-being [3]. The design techniques used during the selected projects range from traditional social science methods like interview, questionnaire or focus group (e.g., P08), to mockup and prototypes (e.g., P01, P02, P10) that enable the users to experiment with the proposed solutions and discuss their experience of use.

4.3 RQ3: Technological Solutions, Systems and Services

The selected projects exploit the potentialities of diverse key-enabling technologies with different functionalities to form a connected ecosystem of wearable devices, sensors embedded in indoor/outdoor environments, smart everyday objects, in addition to personal devices like smartphones, cloud platforms and analytics systems. The following are two example scenarios showing how different tools are combined.

The scenario of the ProAct project (P03) aims to empower the person by promoting a sense of ownership over their health and lifestyle: the smart watch monitors heart rate, sleeping and daily physical activities, while the sensors monitors temperature and air quality in the home; these data are sent to the analytics system in order to inform the caregivers who can plan personalised interventions, as well as to provide useful tips to the older person through a mobile app with a chatbot.

The scenario of the ACTIVAGE project (P02) aims to enable older people to freely and safely move in outdoor contexts: using WiFi network and bus services of the city, the mobile app tracks users' movement and help them get to their destination, while the wristband monitors the physical activity and heart rate; the cloud system collecting the information about the users, through some rule-based processing, detects potential risks and sends direct messages to the user or through other assistance services.

The introduction of home automation and intelligent systems able to collect sensitive data, take actions and provide recommendations, often face the users' scepticism, reluctance and distrust. A way to deal with this is to design non-invasive systems or gamification and persuasive strategies (P03), or to transform everyday objects like a kettle into smart objects (P05).

4.4 RQ4: Trajectories for the Future Design of SCBS

Based on the analysis of the selected projects, we can derive some recommendations for the future design at different levels.

Considering the conceptual framework, the selected projects merge the concepts of Ambient Assisted Living, Smart Home, Smart City with the framework of Active Ageing, to enhance the quality of life of people as they get old. In light of this, the project ProACT (P03) calls for a coordinated and integrated approach, given that most models of care across the EU are focused on a single disease approach, and they are not adaptive to the needs of people with multiple chronic conditions and changing needs. Thus, the future design of SCBS should support person-centred healthcare models rather than single-disease specific approaches, and support the abilities of the person instead of focusing on the impairments [3].

Regarding the methodology, the design of the future SCBS should consider the long-term adoption of the system by the actors involved in the community. As pointed out by Malavasi et al. [15], maintaining the user engagement over time is a crucial challenge to reach the expected impact (e.g., support independent living). But the matter is not merely related to the user's interaction with a single tool, rather for SCBS it depends on the ability of the smart community to remain relevant in the different life stages and according to changing needs of people ageing with disability. To this end, a multidisciplinary team can gather diverse expertise needed to adopt a holistic and life-long perspective (e.g., social sciences, psychology, geriatrics, computer science), as done for the ProACT project (P03).

Concerning the technological implementation, the main issue pointed out by the selected projects is related to the interoperability among different devices, sub-systems and services which are combined in the SCBS [15] [17] [18]. The interoperability issue goes to add to the security and privacy concerns especially when in the case of medical records. Moreover, the introduction of Artificial Intelligence (AI) systems offers great opportunities for diagnosis and personalisation of the care, but they also present some risks. Indeed, there are open debates about how AI should be used to inform decision making, about the accuracy of the predictions and the risks for reinforcing and stereotyping some users' behaviours.

Moreover, the implementation of the SCBS might deal with the lack of infrastructure in some contexts (e.g., remote regions, least developed countries, local informal communities), as well as with the digital divide and the need to train the people to properly use the different technologies.

5 Conclusions

This desk research allows us to propose a definition of Smart Community-Based Service: a model that exploits technologies and services, connects people and places to address the needs of ageing persons with disabilities, to empower its members as well as to promote new business opportunities. This conceptualization poses new challenges which can be summarised as follows:

- The life-long perspective enables to consider the changing needs of the people with disabilities, recognizing the specific needs related to DWA and AWD. Flexibility and personalization are key features to accommodate personal preferences, situational contingencies and contexts.
- A multi-stakeholder approach is needed when designing the connections among different people, services, and places. Besides participatory projects are still a few, co-design is pivotal to design successful solutions and it should be carefully planned to enable the participants to take part in the process according to their abilities.
- The SCBS should orchestrate not only the enabling technologies but also the key-persons in the communities who can act as mediators for some practices (e.g., recreational activities, socialisation), and the focus on functional needs should not overshadow the hedonic needs and a more holistic vision of the experience.

Another relevant issue is related to the role of the ageing person both in the design process and in the use of the SCBS, which can be influenced by stereotypes and ageism: instead of merely being a source of information, and a deficit person to control, the ageing person should be a partner in the design process and the core actor to empower with the SCBS [3] [16] [23].

The review confirms that research on AWD is growing but still limited [10] [13] and the design projects specifically addressing this population are very few [20] and often experimental [3]. In particular, little attention is given to the changing and specific needs related to DWA and AWD. However, the SCBS has potential to create synergies between the services for elderly and persons with disability, addressing cross-population needs and connecting diverse life environments.

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