



Product Service Platform to improve care systems for elderly living at home



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ABSTRACT

Background: Population aging is inducing governments to redesign their healthcare models. One policy measure aimed at reducing healthcare expenditures and improving services is to encourage people to age-in-place. Scientific research has been trying to find ICT-enabled solutions to the growing problem of elderly home care. However, such research is often technology-oriented and neglects the end-user perspective. It does not consider the real needs of older people and all stakeholders involved in their healthcare.

Method: A user-centered design approach was adopted with the involvement of older people, experts dealing with the aging population, and the whole stakeholders' chain. Through surveys, focus groups, and brainstorming sessions, it was possible to determine the main features of the product service platform.

Results: Starting from a large-scale survey of elderly people living in Italy, this paper presents the requirements and the architecture of a product service platform aimed at improving the independence and elderly quality of life. This work proposes an elderly-centered platform that works as an aggregation point of an articulated social health system, provides multiple tailored services, and optimizes the use of local resources.

Conclusions: The involvement of the end-user and all the stakeholders allowed for the consideration of different perspectives and the creation of a value network that aggregates existing services, resources, and information with new opportunities to achieve common benefits. This work provides guidelines on how to develop this type of platform by exploiting the potential of each stakeholder without creating new barriers. Technology, caregivers, and society are combined synergistically to provide tailored services able to satisfy specific users' needs.

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Introduction

Owing to improved public health facilities and declining fertility rates [1], two trends that are expected to continue in the coming decades, the lifespan of the population in the Western world is increasing rapidly. According to the United Nations [2], the global life expectancy at birth will increase by ten years, reaching an average of 76 years by 2050, and within the next thirty years, the older adults will outnumber children under the age of 15. At the same time, the proportion of people over 80 (i.e., so-called double aging) is expected to triple. In particular, in Europe, the number of older people is expected to increase by approximately 50% from 2000 to 2050, which includes a sudden rise in the number of ultra-octogenarians [3].

Moreover, over the years the common family model has been changing from a patriarchal model to a more distributed model,

wherein sons live far away from their parents because of job opportunities [4]. Therefore, current caregivers have to appeal to people outside the family. Nevertheless, this is a short-term solution that does not improve the quality of life of older people and represents a considerable cost for the entire family. As a result of this environment, it has been noted that older people who live alone require a new assistance model that is more adequate from a healthcare point of view as well as from a social perspective. Especially in Italy, the basic healthcare model is based on a reactive approach rather than a preventive one; the current model is lacking in initiatives capable of incorporating interdisciplinary institutions and skills. Hence, there is a requirement for a significant reduction in patient hospitalization, which will increasingly shift care and monitoring phases into the homes of patients. The cost of assistance accounts for a majority of national budgets and is often a source of significant waste.

Therefore, the current healthcare model is often considered inappropriate and insufficient for providing adequate services and fulfilling the needs of people, especially older ones [5]. This

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highlights an evident need to improve the current healthcare model that cannot support such an increasing elderly population with high-quality services [6]. In this context, technology is often seen by public authorities and certain professional sectors as a potentially useful tool to allow older people to remain longer in their own homes [7].

During the past few years, scientific research has been trying to find technological solutions to the growing problem of home care for elderly people, and smart objects [8], robots [9], smart environments [10], and platforms [11] have been developed. However, the research is often technology oriented and neglects the perspective of the end-user. Technology-driven initiatives often do not consider real end-user needs, which requires the investigation of expressed (e.g. home assistance) and latent (e.g. social inclusion) needs. The former requires the integration of older people into the product/service development process whereas the latter entails co-designing experiences with all stakeholders involved in elderly healthcare [12].

The aim of this study is to define a new kind of product service platform (PSP) aimed at improving the living conditions of older people and to overcome the present difficulties in providing care. To accomplish this, the following steps have been taken: the first one is a deep analysis of a sample of Italian older people living at home, followed by a focus group with experts dealing with the aging population to discover the main needs of the sample of older people. Based on the obtained results, a further focus group was conducted to identify functional and non-functional requirements of the platform to improve access, affordability, and stakeholder engagement with healthcare. Through several brainstorming sessions, these requirements were detailed, and a comparison was made with existing platforms. Owing to this, it was possible to describe the architecture of a more adequate PSP and rationale behind the creation of tailored services and determine the optimal tradeoff between technology, caregivers, and society. At present, the PSP has been completely designed and is being implemented. This hybrid platform is composed of virtual and physical elements. The virtual element consists of a web-based platform, which includes three main modules and digital technologies that allow information sharing on any device, from any location, and with multiple stakeholders. This platform also allows online access to services, the performance of some tasks with a few clicks, intelligent data management, real time feedback, and remote monitoring of older people. The physical elements include persons (e.g. employees, volunteers), infrastructure (e.g. office, aggregation centers), medical devices, and means of transport.

State of the art

Several studies have emphasized the potential benefits of using ICT, particularly for the elderly [13]. It has been proved that web-based interventions can provide accessible support to family caregivers to offset declines in their health and wellbeing [14]. However, older people are seen as a group in which the possibilities presented by these technologies are marginalized by issues of access and use. The goals set up for internet of things (IoT)-enabled technology in personalized healthcare systems are not easily reachable, and there are still many issues to deal with [15]. Although smart homes can non-invasively enhance home care for the elderly and people with disabilities, providing adequate information flow between stakeholders is still an open challenge [16]. Providing older people with a health-coordinating center, which integrates and manages the data from various devices and then provides comprehensive and easily understandable feedback, is crucial [17].

Another useful instrument to help older people in their daily lives is the service platform, which can be regarded as an IT artifact that enables, shapes, and supports the business processes

needed to deliver products and services and improve the value proposition to those who use the platform [18]. The services provided by such a platform are various. Many commercial platforms propose services for activity coaching, nutrition, sport, serious games, and assistance. Usually, a platform allows an older person to be more proactive in maintaining their health and wellbeing and can be customized depending on the person's desires and needs. The general aim is to enable a community-based approach to aging at home. Moreover, a platform usually monitors the health conditions of the user: if someone has a fall in the house, a caregiver or a doctor would be alerted thanks to the IT devices installed in the house and connected to the platform.

Based on the platform overviews performed by Keijzer-Broers [19], most platforms connect (professional) caregivers and elderly people (i.e., b2c). Other platforms position themselves as tools for a personal care plan or elderly management solution that can be used to manage health information and share it with families and caregivers (i.e., c2c). However, there are some platforms that serve as a matchmaking platform between elderly people and caregivers and also provide an online e-commerce marketplace that facilitates the buying and selling of products or services for independent living. In addition, these kinds of platforms have a "community" feature, where end users can ask questions and take part in online conversations. Although these last platforms can be considered as complete, there are no platforms that provide smart living products and services and simultaneously encourage social interaction. Considering the fact that all the stakeholders in these last platforms are from the healthcare sector, it is clear that there are no platforms that involve multiple stakeholders from different sectors in the smart living domain related to health and wellbeing [15,19,20,21].

In fact, at the moment, no service platform exists that involves more than one group of stakeholders and fosters matching between demand and supply of products and services for independent living. Although product service system applications have huge potential for the healthcare industry, research around this topic is very scant [22]. This evidence suggests we should rethink the existing PSP architecture to create a proactive and collaborative environment able to support the active aging. To address this lack, this paper defines the main requirements that a new hybrid PSP should satisfy and describes how it should work and involve all the stakeholders.

Analysis of urban living environment of older people

As anticipated, to discover the major requirements of a PSP for health and wellbeing, a survey with a significant sample of elderly people and two related focus groups were conducted.

The study involved 1346 of the 2459 inhabitants over the age of 75 of eight municipalities of the inner areas of the Marche region (Italy), which are affected by depopulation and lack of territorial enhancement. As described by the authors in [23], data were gathered by an ad-hoc questionnaire consisting of two sections. The first included closed-ended questions focusing on socio-demographic information, house characteristics and accessibility, mobility, and social relationships. It was filled in with the support of municipal employees (i.e., general register office, social welfare office, technical office), who know the context well and interact with the older people in the community every day. The second was carried out with the help of general practitioners (GPs). It investigated the users' state of health according to the activities of daily living scale (ADL) [24], which analyzes the six basic human functions (bathing, dressing, toileting, transferring, maintaining continence, and eating), and the geriatric functional rating scale (GFRS) [25] that evaluates the functional capacity of senior patients. The former allows classifying the level of impairment as

Table 1
Older people sample characterization.

| | Class 1 | Class 2 | Class 3 |
|---|-------------|-----------|-------------|
| Gender | | | |
| Female | 539 (40,4%) | 37 (2,8%) | 167 (12,5%) |
| Male | 465 (34,9%) | 31 (2,3%) | 94 (7,1%) |
| Age | | | |
| 75–84 | 743 (55,7%) | 25 (1,9%) | 80 (6,0%) |
| 85–94 | 241 (18,1%) | 36 (2,7%) | 154 (11,6%) |
| 95+ | 13 (1,0%) | 6 (0,5%) | 24 (1,8%) |
| House location | | | |
| Living in the center or district | 807 (60,5%) | 57 (4,3%) | 205 (15,4%) |
| Living in an isolated house | 187 (14,0%) | 10 (0,8%) | 50 (3,8%) |
| Cohabitants* | | | |
| C1 | 387 (29,0%) | 16 (1,2%) | 73 (5,5%) |
| C2 | 69 (5,2%) | 4 (0,3%) | 10 (0,8%) |
| C3 | 288 (21,6%) | 15 (1,1%) | 44 (3,3%) |
| C4 | 13 (1,0%) | 8 (0,6%) | 41 (3,1%) |
| C5 | 1 (0,1%) | 0 (0,0%) | 5 (0,4%) |
| C6 | 14 (1,1%) | 2 (0,2%) | 30 (2,3%) |
| C7 | 7 (0,5%) | 18 (1,4%) | 109 (8,2%) |
| C8 | 206 (15,5%) | 23 (1,7%) | 54 (4,1%) |
| Participation to social activities | | | |
| None | 184 (13,8%) | 32 (2,4%) | 199 (14,9%) |
| Recreational activities | 102 (7,7%) | 5 (0,4%) | 7 (0,5%) |
| Religious activities | 378 (28,4%) | 21 (1,6%) | 41 (3,1%) |
| Both | 331 (24,8%) | 10 (0,8%) | 11 (0,8%) |
| Own car | 516 (38,7%) | 21 (1,6%) | 1 (0,1%) |
| Katz index | | | |
| 0 | 925 (69,4%) | 29 (2,2%) | 39 (2,9%) |
| 1 | 36 (2,7%) | 3 (0,2%) | 13 (1,0%) |
| 2 | 14 (1,1%) | 6 (0,5%) | 12 (0,9%) |
| 3 | 25 (1,9%) | 18 (1,4%) | 46 (3,5%) |
| 4 | 2 (0,2%) | 3 (0,2%) | 5 (0,4%) |
| 5 | 2 (0,2%) | 1 (0,1%) | 27 (2,0%) |
| 6 | 0 (0,0%) | 8 (0,6%) | 119 (8,9%) |

*C1 = cohabitants under 75 years; C2 = cohabitants both over and under 75 years; C3 = cohabitants over 75 years; C4 = cohabitants under 75 years and caregiver; C5 = cohabitants both over and under 75 years and caregiver; C6 = cohabitants over 75 years and caregiver; C7 = caregiver; C8 = no cohabitants.

follows: little (2 or fewer points), moderate (3–4 points), or severe (5–6 points). The latter allows grouping the sample according to the need for institutional care: class 1 is able to function alone, class 2 is able to function with some assistance, and class 3 needs institutionalization. Missing data rates among questionnaires were low (1%); only 13 questionnaires were excluded. The main results are summarized in Table 1 (null answers were not included in the computation). Key findings show that the elderly who live with relatives, spend their free time in religious or recreational activities, and have no illnesses or infirmities are more likely to be able to live in their own homes. People in poor health or people who live in an isolated house and do not have a car are more prone to isolation and loneliness (frailty status). People over 85, especially females, who have compromised physical and/or mental conditions are more likely to request care in a suitable institution. Indeed, the more severe the impairment is, the more likely the presence of informal caregivers.

As described by the authors in [26], the focus group meetings were organized in two phases: the first phase was used to individuate the users' needs, while the second one was used to determine the main PSP requirements. Experts dealing with the aging population from a practical and a research point of view were involved in each meeting. These experts included five GPs, two researchers from an elderly research hospital, two informal caregiver representatives, two supporters of voluntary associations involved with older people, six mayors of local communities, and three university researchers. The focus group sessions were conducted by the same facilitator and lasted for approximately 90 min each. First, the moderator welcomed the participants and shared the goal of the event, the information gathered by the survey, and the manner in which

Table 2
Focus group–User needs.

| Need (N _i) | Mean Value | SD |
|---|------------|-----|
| N1. Improve older people's social relations and activities | 6.6 | 0.5 |
| N2. Optimize community resources | 5.5 | 1.2 |
| N3. Ensure older people safety and wellbeing | 6.4 | 0.7 |
| N4. Systematize voluntary associations | 5.3 | 1.8 |
| N5. Make the GP role more effective | 6.1 | 1.0 |
| N6. Improve information exchange between stakeholders | 5.1 | 1.5 |
| N7. Improve home help services | 5.5 | 1.1 |
| N8. Increase accessibility and quality of provided services | 6.5 | 0.5 |
| N9. Improve the community's economic exchanges | 5.1 | 1.0 |

Table 3
Focus group–Requirements.

| Requirement | Mean Value | SD |
|--|------------|-----|
| Detailed information about community activities | 4.9 | 1.1 |
| Integration with existing information systems | 5.5 | 1.3 |
| Managing administrative activities (e.g. reservation, bills payment) | 5.3 | 1.1 |
| Marketplace for products and services | 5.6 | 1.3 |
| Multichannel communication | 6.1 | 0.7 |
| Physical and virtual access (e.g. office, call center, web) | 6.2 | 0.9 |
| Tailor-made services | 6.3 | 0.7 |
| User healthcare conditions monitoring | 5.8 | 1.0 |

the results would be used. Then, he encouraged open exchanges and discussions among the members of the focus group according to content-oriented research methods. Finally, he summarized the users' needs (PSP requirements) as determined from the first (second) session and asked each expert to express their agreement with each item according to a 7-point Likert scale (i.e., 1 = strongly disagree, and 7 = strongly agree). The outcomes of the first focus group and the evaluation of the survey results have led to the identification of user needs with a relative mean score and standard deviation (Table 2). The ratings suggest that the improvement of older people's social relationships is the primary way to reduce declines in health along with increasing the quality of the services provided. It also emerged that ensuring the safety and wellbeing of older people together with making the role of GPs more effective are among the most valued needs.

The second focus group focused on the evaluation of the PSP general requirements. In particular, eight main requirements emerged (Table 3). Although the average scores for all the requirements are quite high, some differences did arise. Participants identified tailor-made services, multichannel communication, and physical and virtual access as the most advantageous requirements. Monitoring the condition of user healthcare was also indicated as useful.

PSP requirements design

The focus group outcomes highlight how the PSP design should be based on a user-centered approach aimed at promoting active aging and independent living for older people. Based on this cornerstone, stakeholders with different backgrounds and competencies such as GPs, medical specialists, mayors, assessors, formal and informal caregivers, volunteer association representatives, social workers, local entrepreneurs, economists, and engineers were involved in a series of brainstorming sessions to support the PSP design. The aim was the definition of a set of solutions and functionalities for the PSP, given the list of users' needs and main requirements established previously. Stakeholders found themselves collaborating for the first time on an innovative theme in order to bring out innovative ideas and support the so-called "contamination" between different sectors. Each person was called on to propose his/her own ideas upon all topics, regardless of his/her

specific competence, stimulating personal creativity. The brainstorming was also supported by the use of post-it notes, which simplified the final discussion. At the end of the creative phases, a debate was opened, and the ideas were analyzed to investigate their effectiveness and feasibility. During this phase, the hanging post-it notes were moved or modified to follow the discussion. As a result, the following requirements (R_j) were defined.

R1. *Aggregation point*. The PSP should be able to act as an aggregation point of an articulated social health system, including existing and new services. It should be a reliable reference for older people and their caregivers, and it should work as a user-friendly interface with society, simplifying everyday activities.

R2. *Multiple stakeholders*. The platform should create a network between citizens (i.e., older people and formal/informal caregivers), service providers (i.e., public and private companies in the health and wellbeing sector), and local governments. The aim is to create a multi-sectorial network of interest to face current challenges from different perspectives, promote active dialogue, share experience, knowledge and information, establish and maintain effective relationships on multiple levels, and integrate the supply of products/services. This will allow the development of a new welfare model from which the whole community can benefit.

R3. *Physical and virtual access* (e.g. office, call center, web). The platform should be usable by as many people as possible, thus simplifying bureaucratic processes and increasing people's awareness. Older people can interact with PSP reference persons when they wish to do so; this will allow them to overcome their barriers to adoption and attitudes towards technology. On the other hand, other stakeholders can easily access the platform online through their personal accounts, regardless of the operating system and device that they use.

R4. *Privileged Access Management*. According to an individual stakeholder's role, the PSP should manage access and permissions. Controlling and monitoring privileged access is extremely important to mitigate the risks related to data management, ensure privacy compliance, and adapt the interface in terms of content and usability.

R5. *Multiple services*. The PSP aims to integrate all services into a single platform. This includes existing and new services. As many services categories as possible should be covered, considering different domains such as the social (e.g. social events or activities, shopping delivery, video calls), health (e.g. specialist examinations, nurse home), and administrative (e.g. reservation, bills payment) domains.

R6. *Remote health monitoring*. Systems and solutions to remotely support and manage diagnoses and wellness should be included in the PSP. It should be a useful tool to monitor the health of the elderly (e.g. through telemedicine devices), predict the symptoms of certain chronic diseases, decentralize specialist skills (teleconsultancy, telemonitoring, etc.), and improve peripheral first aid points. GPs will not focus on established diseases and/or disabilities but will implement a preventive approach that can slow down the functional decline of older people.

R7. *Tailor-made services*. A set of rules to match the user's profile with the platform's services should be defined in order to create tailored projects and ensure that they fit well with the needs of individuals. Finding the optimal trade-off between technology (e.g. smart devices, telemedicine platforms, holter, etc.), caregiver support (e.g. homecare assistance), and social involvement (e.g. volunteer network, social events, etc.) plays a key role in ensuring people's wellbeing and allows them to overcome disabilities, isolation, depression, etc. For this aim, the PSP should integrate knowledge-based or machine learning algorithms to cluster the users and correlate a single product/service, or a combination of them, with the most significant user

characteristics/indicators enabling simple rules like "if-then" statements or more sophisticated inference processes.

R8. *Indicators and thresholds*. A multidimensional assessment (e.g. comorbidity, quality of life, context characteristics) is essential to conduct screening activities, define the abovementioned project, and evaluate its progress over the time. A set of protocols, indicators, and thresholds has to be implemented to adopt an iterative approach towards improving the satisfaction of the elderly and to generate effective warnings or rewards.

R9. *Alarms management*. The alarm system has to be properly managed in order to avoid security event information overload and ensure the proper resource involvement. For each event, the most proper intervention strategy (e.g. message to family, notifications to the GP, call to the 24/7 monitoring center) should be defined and adopted.

R10. *Information management*. The PSP represents a valuable tool for gathering information from several sources and can enable different information flows as needed. Integration with existing information systems plays a key role to ensure data coherence, consistency, and updates. Moreover, an effective dissemination strategy can increase people's awareness and trust, offer job opportunities, stimulate participation in upcoming events, etc.

R11. *Privacy*. It is one of the most important prerequisites of the PSP. It must be ensured to prevent unauthorized identification and tracking.

R12. *Resource management*. The creation of an integrated network allows the use of local resources in the most efficient way possible. The enrollment of new volunteers with different skills or passions should be promoted in order to enrich the range of services offered. The final aim is to achieve best matching between the resource profile, services, and people's needs.

R13. *Training*. To ensure high quality services, specific training programs should be implemented. They can involve different stakeholders (e.g. caregivers, older people, network resources, etc.). According to specific needs, different training modalities can be adopted (e.g. e-learning, courses, public events).

R14. *Optimization modules*. A single platform that involves multiple stakeholders and offers multiple services should exploit specific optimization modules aimed at making the resource management (material, human, financial) more efficient (e.g. transport services).

R15. *Marketplace for products and services*. The PSP should work as marketplace in order to reduce the gap between supply and demand and provide a good opportunity for local companies to offer their services in a reliable and effective way. In this way, the territory can be revitalized.

R16. *Scalability*. Scalable architecture solutions should be adopted in order to adapt the PSP to different contexts (i.e. target users, territories, domains) and exploit new opportunities in terms of services, stakeholders, modules, etc.

Benchmarking of most known platforms

Based on the above-mentioned requirements, a real PSP was designed and its ability to satisfy the users' needs was investigated using the quality function deployment (QFD) method [27], which allowed us to determine in a systematic and objective way how the technical and functional features of a product satisfy customer needs. Table 4 contains the scores expressing the relevance of each requirement (R_j) to satisfy each specific need (N_i). A 3-class value related to the strength of the relationship (9 - Strong, 3 - Medium, 1 - Weak, 0 - No correlation) was assigned. Then, the absolute importance (AI_j) of each requirement was calculated as the sum of all contributions obtained from all considered needs. The relative importance (RI_j) was calculated by multiplying each score by the

Table 4
Correlation between needs and PSP requirements.

| N/R | w | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 |
|-----------|-----|-----|-----|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| N1 | 6,6 | 3 | 1 | 9 | | 9 | | 9 | 3 | 1 | 3 | | 3 | | | 1 | |
| N2 | 5,5 | 9 | 3 | | | | 1 | 3 | 1 | | 3 | | 9 | 1 | 9 | | 3 |
| N3 | 6,4 | | | | 1 | 9 | 9 | 9 | 3 | 9 | | 3 | | 1 | | | |
| N4 | 5,3 | 3 | 9 | | | 3 | | | | | 1 | | 3 | | 3 | 3 | 9 |
| N5 | 6,1 | | | | 1 | | 9 | 3 | 9 | 9 | 3 | | 3 | 1 | 1 | | |
| N6 | 5,1 | 1 | 9 | | 9 | | | | | | 9 | 9 | | | | 9 | 1 |
| N7 | 5,5 | | | | | 9 | 9 | 3 | 9 | 9 | | | 3 | | | | |
| N8 | 6,5 | 9 | 1 | 9 | 1 | 1 | | 3 | 9 | 9 | 3 | 3 | 9 | 1 | 3 | 3 | 9 |
| N9 | 5,1 | 1 | 3 | | | 3 | | | | | 9 | | 9 | 3 | 3 | 9 | 9 |
| AI | | 26 | 26 | 18 | 12 | 34 | 28 | 30 | 34 | 37 | 31 | 15 | 24 | 21 | 17 | 25 | 31 |
| RI | | 154 | 139 | 118 | 65 | 204 | 168 | 188 | 207 | 227 | 171 | 85 | 130 | 128 | 93 | 134 | 174 |

Table 5
Platform benchmarking.

| Requirement | MyMate | T-seniority | SMART2 | OMNIACARE | HEREIAM |
|-------------|--------|-------------|--------|-----------|---------|
| R1 | • | •• | | | |
| R2 | •• | ••• | • | • | •• |
| R3 | ••• | | | | |
| R4 | • | ••• | • | ••• | N/A |
| R5 | •• | ••• | | | •• |
| R6 | | • | ••• | ••• | • |
| R7 | • | • | • | | |
| R8 | •• | | •• | • | |
| R9 | • | •• | ••• | ••• | •• |
| R10 | | | | | |
| R11 | •• | N/A | N/A | ••• | N/A |
| R12 | ••• | | | | |
| R13 | | | | | |
| R14 | | | | | |
| R15 | • | • | | | • |
| R16 | ••• | ••• | N/A | •• | N/A |

weight of its corresponding need (w , obtained from Table 2) and by summing all contributions for each requirement.

As the results show, all needs are well covered. In particular, the ability to provide tailored services belonging to different domains, evaluate progresses/warnings over the time and consequently react resulted in increased satisfaction of the whole stakeholders' chain.

From benchmarking analysis, it was found that the existing platforms hardly cover all requirements (Table 5). This research was conducted by looking for relevant works within the main on-line databases of scientific literature (i.e., Scopus, ScienceDirect) and the primary information source for EU-funded projects (i.e., CORDIS). The following keywords were used and combined: "older people", "elderly", "healthcare", and "platform". A manual screening of cross-references was also performed. Then, the platforms that best met the requirements were selected. In particular, T-seniority [28] and HEREIAM [29] offer a set of services, related to healthcare, shopping, and social life that can be accessed via digital TV. OMNIACARE [30] is a modular hardware/software system designed for medical and care assistance. SMART2 (Self-Management supported by Assistive, Rehabilitation and Telecare Technologies) [31] introduces home-based assistive and rehabilitation telecare technologies to facilitate the self-management of chronic diseases such as chronic pain, congestive heart failure, and stroke. MyMate [32] adopts an innovative gamification approach to create a network of elderly volunteers that provides informal care and fosters social relationships. There are also open platforms aimed at facilitating the development, distribution, and deployment of technological solutions for ambient assisted living (AAL) [33]. These are only few of the numerous projects across Europe and Italy, demonstrating both the significant efforts of the research community and the real barriers that limit their success. The proposed PSP aims to overcome the current gap through the aggregation,

valorization, and optimization of existing services and the creation of tailored services. For this aim, the product/service portfolio follows a modular approach (e.g. a subset of devices connected to the telemedicine platform) that enables the definition of various tailor-made solutions according to specific indicators that are constantly updated (e.g. Katz index [34]) and other complementary information (e.g. technological skill level). It is based on a matching between these data and each product/service module that defines its level of indispensability (priority) and deliverability.

PSP content design

The PSP has been designed for older people who live in their own dwelling and want to remain at home as long as possible. The aim is to help older people to remain active and independent and not have to leave their houses in favor of nursing homes. The mapping of existing services and the relative analysis of good practices supported the identification of important PSP services and their classification in the following categories:

- Organizational services that support citizens in bureaucratic, administrative, and booking procedures (e.g. payments, management and reservation of medical check-ups, etc.)
- Social services, which cover a range of public services provided by the government, private, profit, and non-profit organizations intended to aid vulnerable persons and build stronger communities (e.g. organization of social activities, transport to the main social points of interest (POIs), etc.)
- Health services that include urgent services and medical emergency responses (SUEM 118) and preventative, rehabilitative, long-term, hospital, diagnostic, primary, and home care services, provided by public and private entities such as primary care providers, nurses, specialists, and pharmacists (e.g. home healthcare, check-up health point, etc.)

PSP services have been analyzed from three different points of view: technology, caregivers, and society. This approach allowed us to identify the optimal combination of these three factors and establish the rules necessary to provide personalized, innovative, and high-quality services that are also economically sustainable.

The architecture of the proposed PSP is shown in Fig. 1. In particular, the physical part of the PSP is the physical interface with end-users and includes the following elements: (a) Infrastructure such as offices, social centers, etc., (b) Employees responsible for managing the PSP and interacting with end-users (calling, visiting, provide information, etc.), (c) FacileCare® HealthPoint that can be fixed (health corner at pharmacies, clinics, etc.) or mobile to be used by health professionals to carry out home medical check-ups, and (d) Means of transport to ensure the user's mobility from/to DPI.

The virtual part of the PSP consists of the web application and several DBs for the management of data related to users, products,

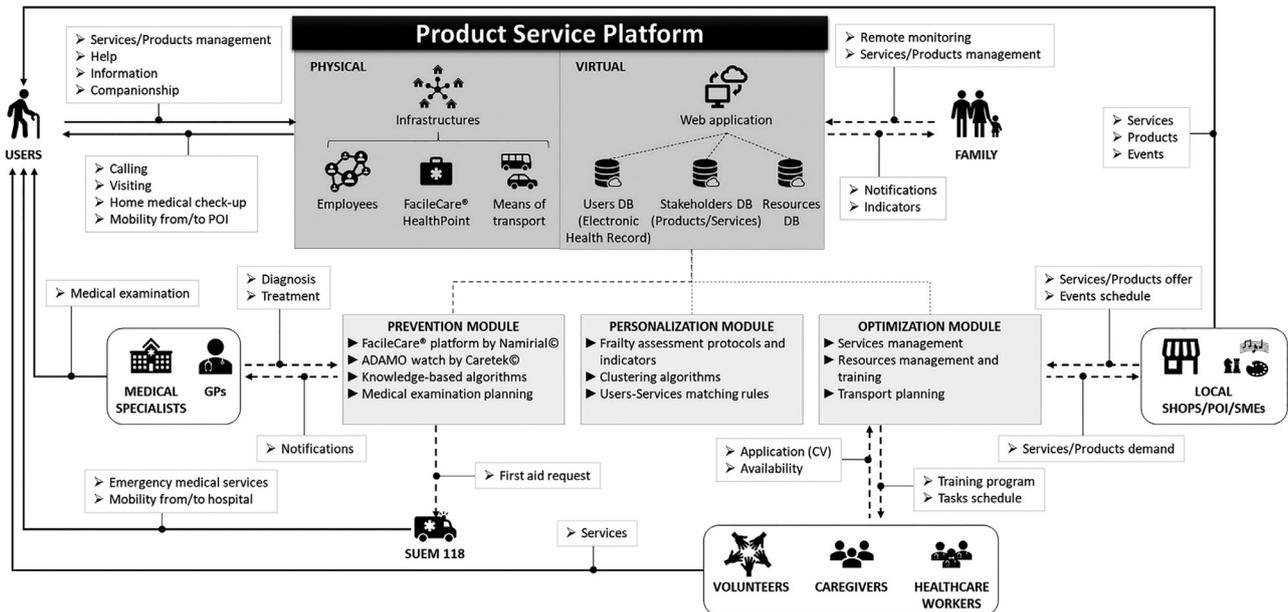


Fig. 1. PSP architecture.

services, and resources. It allows online access and management of the PSP services by the family or other stakeholders as well as remote monitoring of older people. It includes the following three main modules:

- *Prevention module* that supports medical specialists and GPs in the monitoring of users' health via IoT devices (e.g. an ADAMO watch acquires and analyzes user data and, if necessary, generates a first aid request), planning of medical examinations and ad-hoc algorithms that generate notifications with different levels of priority according to set thresholds.
- *Personalization module*, which aims to define the best service pack for the users according to frailty assessment protocols and indicators.
- *Optimization module* that is responsible for the management of service demand and offers as well as the selection, training, and allocation of resources and transport optimization.

The role of technology in the PSP

Technology has become a powerful way to improve the quality of personal services and, at the same time, increase their efficiency. In recent years, many technological solutions have been developed and commercialized to improve the efficacy of the services provided and make them more economical.

The PSP is based on a technology platform (web-based) that connects all stakeholders involved in older people's healthcare into a single tool, allows information exchange, and manages requests and services. It represents the core of the elder care system and allows the development of a local marketplace that can reduce the gap between supply and demand. The platform is connected with the other available technologies developed for personal care such as telemedicine devices and applications (i.e., FacileCare® Health-Point and FacileCare® platform by Namirial©) and smart objects (i.e., ADAMO watch by Caretek©).

The most suitable technologies available on the market were selected through scouting performed by experts dealing with the aging population. This has made it possible to identify the most suitable technology for the provided service. The technologies analyzed were clustered into product families and evaluated based on their functions (Table 6).

Table 6
Existing technologies and associated services.

| Smart Object family | Service goals |
|---|----------------------------|
| Home Safety devices (e.g. motion detector, IP camera, gas detector, etc.) | Ensuring security/safety |
| Activity Monitor Devices (e.g. GPS tracker, etc.) Home sensors (e.g. sleep monitor, etc.) | Managing general symptoms |
| Health Monitor Devices (e.g. heart rate, blood pressure, fall detector) Telemedicine devices Medication management system (e.g. pills or medication reminder, etc.) Medical Alert System | Caring for health |
| Wearable Sensors (e.g. fitness and activity trackers, etc.) | Managing physical activity |
| Video calling devices (e.g. smartphone, tablet, pc, etc.) | Socializing |

The classification was made according to the following five functional attributes: adaptability, diagnostic aid, feedback typology, human activity support, and information quality. For each category, a 3-point scale has been defined to objectively evaluate the characteristics (Table 7). The results are summarized in Fig. 2.

The evaluation revealed that few devices are able to adapt to older people's needs (multisensory feedback, adaptability) and to support them in their daily activities. In particular, most of the products (about 75%) do not have a configurable setup and use only one sensory channel (i.e., audio, visual, tactile). In addition, about 20% of them give only monitored parameters and few products allow 24-h monitoring of the user or are able to perform complex medical tests. It is therefore necessary to select the most suitable technology according to the older people's needs and to connect them with the other stakeholders of the platform (i.e., caregivers and society).

The role of caregivers in the PSP

From an eldercare perspective, informal and formal caregivers are the figures who deal with the health and wellbeing of the elderly person. An informal caregiver is usually a family member

Table 7
Scores used to evaluate the technology.

| Feature | Score | Score assignment criteria |
|------------------------|-------|---|
| Adaptability | 3 | Automatic set-up according to the user profile |
| | 2 | Configuration can be customized according to the user preferences |
| | 1 | Multi-user product which requires a manual set-up |
| | 0 | Set-up configuration not editable |
| Feedback typology | 3 | Cleverly management of emergency situations |
| | 2 | Feedback by different sensory channels and alert notification |
| | 1 | Feedback by different sensory channels or alert notification |
| Information quality | 0 | Feedback by only one sensory channel and do not generate alert |
| | 3 | Useful advises to improve the behaviour of the user |
| | 2 | Historical data and make user aware about information significance |
| Human activity support | 1 | Historical data or make user aware about information significance |
| | 0 | Provide simple data |
| | 3 | Support cognitive activities |
| | 2 | Support physical or rehabilitative activities |
| Diagnosis aid | 1 | Support and simplify the product use |
| | 0 | Do not provide any support |
| | 3 | Allow complex medical test |
| | 2 | Offers 24 or 48-hour Holter monitor testing |
| | 1 | Product with medical certification (e.g., FDA, EU Directives, etc.) |
| | 0 | Provides data related to a single test |
| | 0 | |

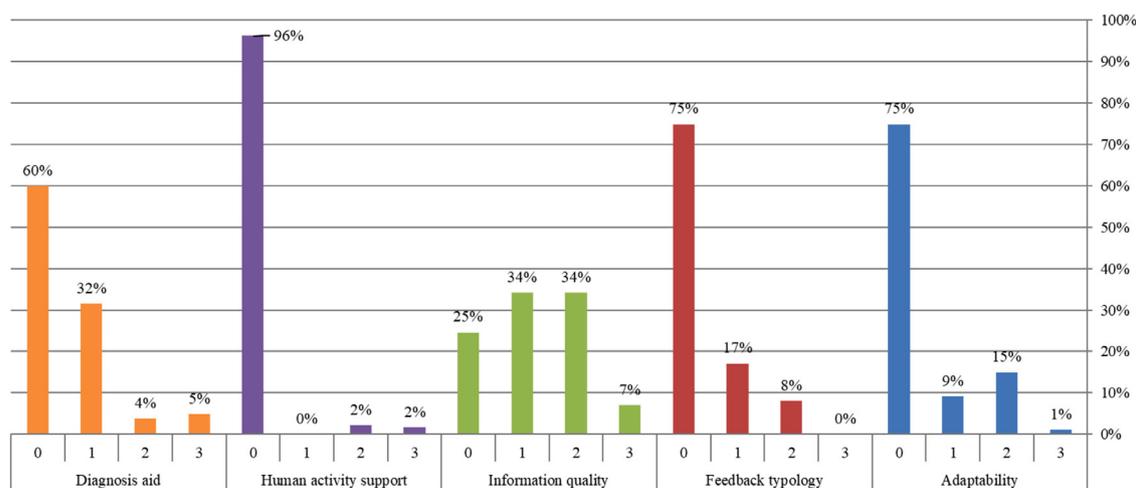


Fig. 2. Functional feature evaluation results.

who aids and supervises the daily care of a relative. They provide services on a daily basis like listening to the care recipient, giving companionship and phone contact, assisting with meals and medication, and helping with worries, anxieties, and emotional needs. A formal caregiver, in contrast, is someone, typically over age 18, who provides assistance to another person who is no longer able to perform the critical tasks of personal or household care necessary for everyday survival.

Over the years, caregivers have become key figures in elderly care as many older people remain alone without the support of their family members. Although the demand for caregivers is high, there is often a shortage in the supply. Therefore, eldercare is entrusted to foreign workers that are often unlicensed and work beyond the oversight of regulatory bodies. In addition, communication barriers and cultural differences between caregivers and patients as well as the problems posed by insufficient professional training often arise. Therefore, this individual and temporary solution represents a considerable cost for the entire family that is not always justified by an improvement in the quality of life of the older person.

For this aim, the PSP involves and integrates all the district's caregivers. Through the PSP platform, they can submit their applications and give visibility to their professional knowledge, skills, and experiences, including feedback and any other elements that

may allow the end-user to make more informed decisions. The PSP connects those who need a care service with persons who can provide it.

The role of society in the PSP

From a social point of view, the PSP integrates all the stakeholders involved in the care of older people. Elderly care relies on a variety of providers to deliver an array of formal clinical and social services, as well as informal services, in the home setting. These providers include a mix of professional and non-professional personnel, including nurses, therapists (physical, occupational and speech), home care assistants, social workers, physicians, dietitians, homemakers, companions, volunteers, and others. Three main organizations have been identified: the local health authority (LHA), local authorities such as municipalities and consortia of such organizations, and voluntary associations.

The LHA is involved in the PSP and is responsible for health services involving medical specialists (e.g. geriatrician, neurologist, oncologist, orthopedist, etc.) and GPs. The specialist doctors will offer their knowledge to perform ambulatory examinations and/or provide medical reports on the patient's state of health through telemedical devices. The GPs will be involved in the continuous monitoring of the state of health of the users from a preventive

Table 8
Rules for the definition of tailored services.

| Service | T | C | S | Set... | According to... |
|---|-----|-----|-----|--------------------------|---|
| Caregivers management | ••• | | ••• | T or S | Technology skill level |
| Training | • | | ••• | T/S ↑↓ | Skill to learn |
| Remote monitoring | ••• | •• | • | T/C ↑↓ | Katz index, CIRS |
| Home health care | ••• | ••• | ••• | T/C ↑↓ | Katz index, CIRS |
| Support in housework and gardening | •• | • | ••• | C or (T+S) (T+S) or S | Caregiver skill Technology skill level |
| Support in administrative procedures and payments | • | • | ••• | (T+C) or (T+S) T or S | Caregiver skill Technology skill level |
| Management of medical check-ups | • | • | ••• | (T+C) or (T+S) T or S | Caregiver skill Technology skill level |
| Shopping delivery | •• | | ••• | (T+S) or S | Technology skill level |
| Medical transportation | •• | | ••• | (T+S) or S | Technology skill level |
| Social transportation | •• | • | ••• | C/S ↑↓ | Own car Caregiver skill |
| Social activities/events | • | | ••• | (T+S) or S | Technology skill level |
| Health point | ••• | | ••• | T/C ↑↓ | Katz index, CIRS |
| Information point | ••• | | ••• | T or S | Technology skill level |

healthcare perspective. Through application of technology, it will be possible to promptly and punctually react in the case of a decline in the state of health without the need for useless hospitalizations. The PSP thus improves health services (i.e., smart and personalized health, and more integration and digitization of information) and, at the same time, the perception of the quality of the services offered (e.g., patient will feel heard and understood and he/she will be reassured about his/her state of health).

The municipalities have been integrated into the platform for the provision of community social services, such as transport from/to POIs, the activation of aggregation centers, and integrated home assistance service (ADI), which will be managed by the PSP. The integration of more municipalities into the platform will improve and optimize the economic sustainability of these services. In addition, dedicated training courses will be activated for the caregivers, volunteers, and other stakeholders of the district. Finally, local voluntary associations and commercial business activities were involved for the more simple and specific services such as helping with garden maintenance, home delivery services (e.g., medicines or market products), events planning, or social center management.

Tailored services of the proposed PSP

The services of the proposed PSP are summarized in Table 8. Each service can be provided by one or more “actors” (T-technology, C-caregivers, S-society), according to specific rules, which aim to fit each service with the user profiles.

For example, tasks such as looking for a caregiver, booking a medical appointment, registering for a social event, etc. can be carried out virtually (T, i.e., PSP web application) or physically (S, i.e., PSP personnel) according to the technological skill level of the user. The proper ratio between technologies and persons ($T/C \uparrow\downarrow$) has to be defined to monitor the health conditions of older people. For this aim, indicators such as the Katz index and cumulative illness rating scale (CIRS) [35] could be exploited. Support in housework could be provided by the caregiver (C), if available, or by the volunteer network (T+S), requiring the online service (T), or through the PSP employees (S). The more aspects that are considered when composing the rules, the more accurate the service customization can be.

Conclusions

Starting from a large-scale survey of older people living in the central inner areas of Italy, this paper investigated the requirements that a PSP should have to improve the independence and

quality of life of older people and allow these territories, which suffer from depopulation, to bloom again. Usually, older people cannot express their needs, thus the whole stakeholder chain was involved in focus groups and brainstorming sessions. This allowed the groups to consider different perspectives and create a value network that aggregates existing services, resources, and information with new opportunities to achieve common benefits. This analysis has allowed us to design a PSP that enables new scenarios where technology, caregivers, and society are combined to provide tailored services able to satisfy specific users' needs.

This work provides a guideline on how to develop this type of platform by exploiting the potential of each stakeholder without creating new barriers. For example, ICT can prevent dangerous situations by monitoring specific parameters, but should not limit access to services. Moreover, to make sure that it fits well with the needs of individuals, tailored projects and indicators should be adopted to assess the satisfaction level and ensure continuous improvement. The final aim is to make older people more autonomous, provide them with stronger social inclusion, and prevent improper forms of sanitation or institutionalization.

The need to manage several stakeholders and the difficulty of changing some elderly habits can limit the potential of the PSP. For this aim, proper information flow and an effective business model should be defined and adopted.

Based on these results, a PSP is being developed and tested in the above-mentioned eight municipalities and it will be further enhanced based on feedback obtained from realistic user evaluations. Further research will be conducted to improve, extend, and automate the rules for the creation of tailor-made services (e.g. the definition of a human frailty index).

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