A telerehabilitation platform for cognitive, physical and behavioral rehabilitation in elderly patients affected by dementia

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1 Introduction

Dementia is one of the main causes of disability in elderly people and it causes a dramatic decrease of their self-sufficiency in daily living [1], [2]. Within the current demographic and economic context, the aging and the related neurodegenerative diseases produce a high social impact since they regard the 5% of population with more than 65 years and about the 30% of the population with more than 80 years. It is estimated that there are nearly 7.7 million new cases of dementia each year worldwide, and among these 2.3 million (31%) occur in Europe [3]. For these reasons, the treatment of dementia becomes, year after year, an increasingly compelling priority for the public health system. Currently, a pharmacological therapy to nurse or to stop the worsening of dementia does not exist and the caregivers (relatives or in-home nurses) are mainly responsible for the treatment. In this context, novel solutions are mandatory in order to improve the therapeutic process for subjects suffering from dementia, trying to slow down their loss of autonomy, motor and cognitive impairments, and capability of independent daily-living. In the last years, innovative technologies have been developed, in order to provide mobility aids, personal care improvements, services to patients and caregivers. The final goal is to maximize the home assistance and telemedicine [4], reducing the costs of treatments in health facilities and improving the quality of life of patients and caregivers [5].

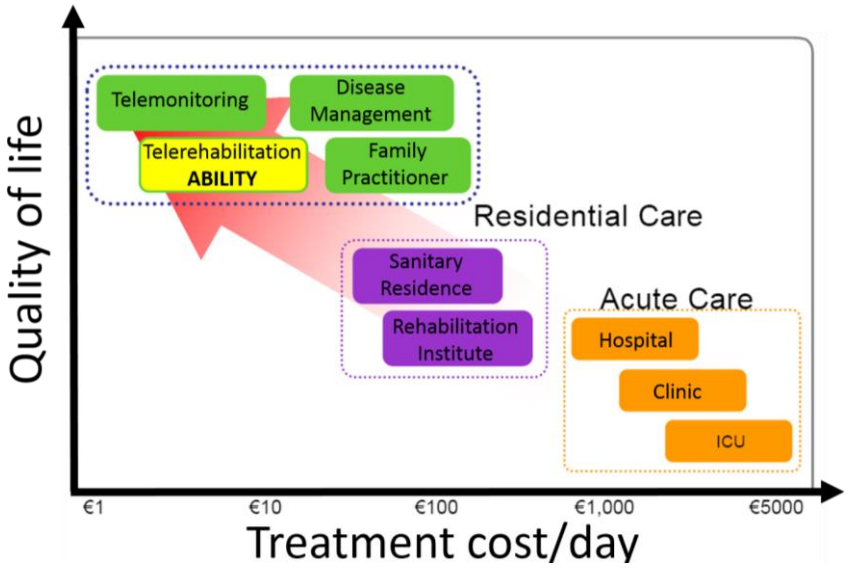

Figure 1: Diagram of different treatment solutions and their impact on patients' quality of life and cost for the national health system (adapted from EHTEL - Intel Workshop eHealth 2020)

In this framework, the aim of ABILITY project is to design, develop and validate an integrated platform of services aimed at supporting and enhancing the rehabilitation process for patients with dementia, with special focus on home-based care. The core of the project consists in a platform, equipped with technology-enhanced devices for motor and cognitive rehabilitation of elderly people suffering from dementia in their favorite environment: their homes [6] [7]. The project is developed through a collaboration of both academic and industrial partners: Telbios Srl, Astir Srl, Teorema Engineering Srl, Secure Network Srl, AB Tremila Srl, Sait Srl, Imaginary Srl, Politecnico di Milano, IRCCS Fondazione Don Carlo Gnocchi, Università degli Studi Milano – Bicocca.

2 ABILITY platform design

The ABILITY platform is a system that aims at supporting continuity of care from clinical practice to patients' home, for patients following a rehabilitation treatment. The ABILITY platform supported by the developed solutions covers a quite wide range of dementia forms, from mild cognitive impairment, to degenerative disorders (e.g., Parkinson, Alzheimer, etc.), and vascular dementia (e.g., post-stroke).

The two main innovation points of ABILITY platform are:

1) The possibility for the clinician to assign rehabilitation plans which will be performed at home, with a strong compliance monitoring made by a Service Center and enabled by the technological solutions integrated;
2) The holistic approach to rehabilitation, as the plan includes physical, cognitive and behavioral therapies/exercises.

The platform foresees several users with different roles:

- patient: which follows the rehabilitation plan, using devices and solutions developed;
- caregiver: which supports the patients and monitors the progresses;
- neurologist: who is in charge of the creation of the rehabilitation plan, as well as of the interface with other doctors and healthcare professionals to provide a care continuity;
- neuro-psychologists and therapists: who follow the in hospital rehabilitation, monitor patient progresses, and may propose changes to rehabilitation plans, to be approved by the neurologist.

Other actors might have access to the platform for visualization of the rehabilitation plans: nurses, residents and internists, other specialist medical doctors, etc.

Furthermore, ABILITY supports the role of the Service Center operator, which is able to check the rehabilitation plans' execution at home and eventually scale up to doctors in case of incompliance. In this case, specific intervention protocols have been agreed with the healthcare professionals to ensure optimal tradeoff between appropriate patients' assistance and minimization of doctors' time consumption.

3 ABILITY platform development

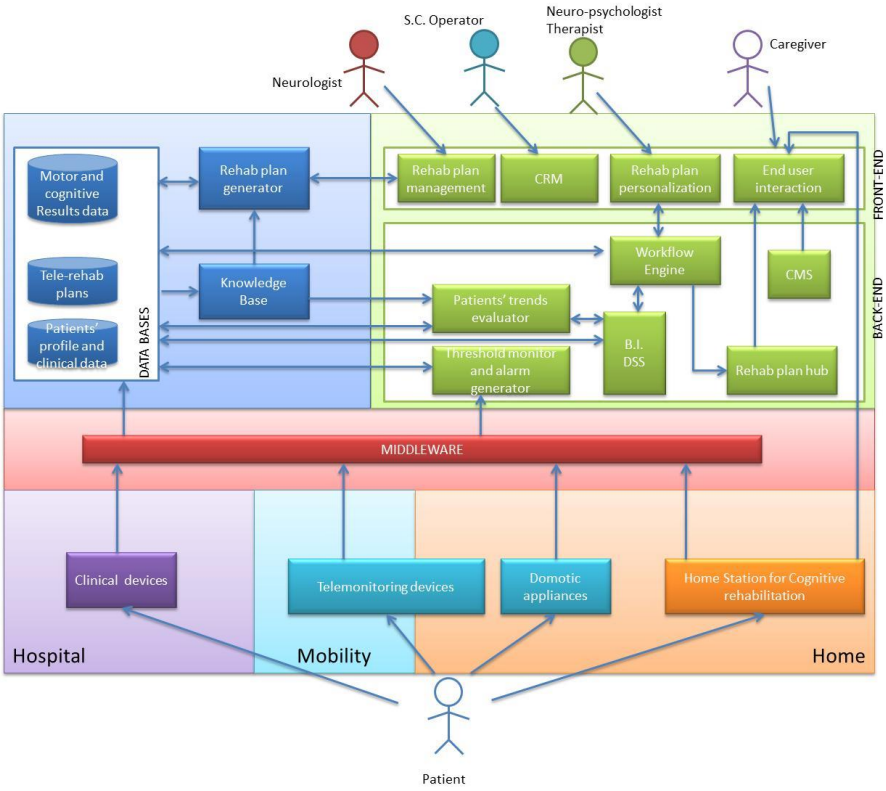

Figure 2: ABILITY platform architecture

Figure 2 represents the logical platform architecture, which can be conceptually divided in three horizontal layers:

1) Patients' side: specific technologies have been developed to monitor rehabilitation plan's at home, at hospital and in mobility. In particular, three kind of devices are provided: devices for cognitive rehabilitation - a home station where the patient can execute the serious games prescribed by the Neurologist; devices for physical rehabilitation - monitoring physical activity; and devices for behavioral rehabilitation (e.g., correct sleep habits, etc.), which also include domotic appliances. In addition, the platform includes devices to monitor the main morbidities (diabetes, hypertension, heart failure, etc.), as

well as devices to perform periodic assessment in hospital - EEG during specific attentive tasks with a user friendly wireless helmet, and mobility assessment with motion capture and gait analysis systems.

2) Middleware layer: which is in charge of managing the communications from heterogeneous devices and systems and forward them to the platform.
3) Platform side: is composed by an infrastructure part (with databases, medical knowledge bases, and rehabilitation plans generator based on semantic reasoning over the data), and an application part. The application part is composed by the front-end, which provides access to the platform functionalities to all the users; and back-end, which provides business intelligence and decision support system tools to facilitate the creation, customization and personalization of rehabilitation care plans, as well as their modification in case of relevant changes.

4 ABILITY platform assessment

The ABILITY platform will be assessed through a set of validation activities, involving a small group of pilot patients, and a Randomized Control Trial (RCT) which will be performed between May and September 2015. Two hospitals have been involved in the RCT, Fondazione Don Gnocchi (Milan) and Villa Beretta (Costa Masnaga, LC). The two centers have heterogeneous populations, belonging respectively to a big metropolitan area and a small rural area. This will ensure the generalizability of the results.

Patients (N=60) will be randomly assigned to a control group (N=30) and to an intervention group (N=30), and they will be selected half from one hospital and half from the other. The control group will receive standard care, meaning 3 rehabilitation sessions per week for 10 weeks in hospital. The intervention group will receive 5 rehabilitation sessions per week for 6 weeks at home, using ABILITY platform. Both groups will have a pre-post analysis of the EEG signals during an attentive task and mobility assessment with motion capture solutions.

The RCT outcome measures include not only variations in the clinical profile of the patients, but also end points related to quality of care, patients' quality of life, burden of disease, and caregiver burden and quality of life.

5 Conclusions

In conclusion, the ABILITY project aims at generating a series of assistive services inside a common platform able to supply, within the rehabilitative therapy, services integrated with the local sanitary system. The platform is intended to be modular and flexible, in order to be adapted to the single patient and his/her needs, increasing the treatment efficiency and efficacy with respect to the state of the art. The ABILITY platform will be carefully assessed through a clinical trial for outcomes produced in terms of rehabilitation and usability in the end-users environment. A secondary aim of the project is to allow the continuation of development of the tested prototypes, born thanks to the collaboration of academic research teams and industrial companies, bringing them up to industrial production.

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