The SENIOR-System of Nudge Theory-Based ICT Applications for Older Patients- Project: A Correlational Study About Neuropsychological and Physiological Data

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Abstract— The SENIOR project (SystEm of Nudge theory based on ICT applications for elderly citizens) was born as an advanced coaching system based on ICT aimed at the detection and management of physiological, psychological and behavioral data coming from older adults addressing the production of (bio)feedbacks related to both practiced physical and mental activities, in order to improve health factors and counteract risk ones that may threaten its balance. The SENIOR system was designed to include a "virtual coach" capable of processing data based on a machine learning process aimed at sending notifications linked to the user's physical and cognitive status. What is recorded by the technologies in use (e.g. wearables and sensors) is in fact sent to a remote server where the data is processed by software and studied to identify patterns linked to dangerous situations that may augment unhealthy attitudes (eg., sedentary lifestyles).

Index Terms—Active ageing, Elderly patients, Nudge Theory, Cognitive decline, Wearable technologies, Quality of life

I. INTRODUCTION

In the future era elderly individuals encounter unique challenges, and the prevalence of physical, social, and mental health issues rises with age. This results in a growing number of elderly people living in the community who have different biomedical and psychosocial needs, potentially limiting their social involvement [1, 2] and self-care abilities. As a result, there is a higher demand for long-term care and support services [3, 4].

To support older people with mild cognitive impairment (MCI) [5-7] in maintaining their autonomy and functional abilities, meeting their health and social care needs, and enhancing their perceived well-being, multi-professional collaboration in primary care is essential. This collaboration should aim to minimize service utilization and expenditure. However, more research is needed [8-12].

Possible impacts of the SENIOR project

Impact on Older Citizens: continuous monitoring and personalized guidance, employing the principles of the Nudge theory, will help slow down the advancement of slight clinical problems and the decline in functional capacities.

Impact on Care Providers: by integrating diverse data through predictive analytics, healthcare providers will gain a deeper understanding of how various factors affect the health of seniors. This insight will enable them to adjust their approach based on the specific needs of each patient, leading to more effective preventive actions.

Scientific and Clinical Impact: technologically-based devices in a home-based scenario could possible reduce hospitalization rates improving disease self-care. This, in turn, will enhance their Quality of Life (QoL). Moreover, increased patient-provider interactions will facilitate greater patient engagement and empowerment. Furthermore, harnessing the power of extensive data analysis and machine learning will not only enhance our comprehension of individuals in their later years dealing with MCI, but also empower us to pinpoint more efficient therapeutic approaches.

Societal and Economic Impact: regarding its impact on society and the economy, citizens will actively participate in decision-making and follow-up procedures. They will engage in virtual communities, sharing their experiences, outcomes, obstacles, and triumphs. This will bolster their motivation and self-efficacy. By providing personalized healthcare and

3878

optimizing the use of available medical resources, we will contribute to the sustainability of both national and local healthcare systems, spanning clinical and societal domains. We will assess the cost-effectiveness of this service using Effectiveness Indicators and Cost Indicators.

II. METHODS

Taking into account the general scenario described in the previous section, the principal aim of the neuropsychological research of the SENIOR project was to study in-depth cognitive and motor functions in a sample of community-dwelling elderly individuals recruited from Milan (Italy), in order to build intelligence algorithms able to integrate psychophysiological and neurocognitive data for orienting older adults towards healthy lifestyle.

The study employed a cross-sectional design.

Ethical approval was obtained from the Ethics Committee of the IRCCS Istituto Auxologico Italiano (protocol ID: 03C824_2018).

Study Participants, Procedure, Measures and Statistical analysis

Participants were recruited from the municipality of Milan (Italy) through advertising initiatives and posters displayed at social centers (AUSER).

Inclusion criteria were the following ones: age between 60 and 85 years; education non less than 5 years; basic ICT. People were excluded in case of severe cognitive and functional impairments that may interfere with neuropsychological test administration and walking upon urban environments.

All participants were equipped with the Howdy Senior System© (Comftech S.r.l., Monza, Italy). The system consists of the Howdy Senior electronic unit (a class IIB medical device), the 'Howdy Senior App' for patient's vital data monitoring on the clinician's smartphone, and a sensory garment (a class I medical device) to be worn by participants during the following motor tasks: 6-minute walking test (BMWT), 10-meter walking test (10MWT), and Time Up and Go Test (TUG).

They were also administered neuropsychological tests assessing global cognition (Montreal Cognitive Assessment, MoCA), selective attention (Visual Search Test, VST), sensitivity to interference (Stroop Color Word Interference Test-abbreviated version, Stroop Test-av), and attentional shifting (Trail Making Test, TMT).

The normality of the collected data was tested by means of the Shapiro–Wilk. Independent samples t-tests were used for normally distributed data and Bonferroni-corrected Mann–Whitney U-tests were used when data did not distribute normally. Spearman's rank correlations were also used to further investigate the association among the neuropsychological and motor measures.

All analyses were run by the Statistical Package for the Social Sciences (SPSS) software for Windows (SPSS, version 23.0; SPSS, Inc., Chicago, IL).

III. RESULTS

The study consists of 85 older adults (M:28; F=57), with a mean age of 73.2 (SD:6.8) and high education (12.4±3.36). All the sample reported a normal MoCA while a pathological score was shown in the Stroop Test-av and in all three components of the TMT, ie. visual processing (TMT-part A), alternate attention (TMT-part B), and divided attention (TMT B-A). The global cognition status did not present any difference between genders while females better performed than male on VST (p=0.004). A significant negative correlation between cardiac functioning supporting the 10MWT and divided attention (TMT-part B and QRS, rho=-0.086, p<0.05; TMT B-A and QRS, rho=-0.812, p<0.05) was found.

IV. DISCUSSION

We confirm that executive decline is a hallmark of cognitive aging. Specifically, we found that divided attention exerts an influence on the heart rate in the 10MWT, which requires a higher use of cognitive resources accounting for greater physiological activation of the sympathetic system.

V. CONCLUSION

The study carried out on the recruited sample allows us to limit the gap present in the literature regarding the shortage of data relating to the motor tests carried out on elderly subjects and to look for potential correlations with cognitive tests depicting the quality of mental abilities in the elderly.

The possible future role of Nudge Theory

A "nudge" forms the foundational element in defining choice architecture, which involves designing various ways to present choices to users while considering how suggestions can impact the decision-making process of the user. "Nudge Theory" suggests that positive reinforcement and indirect suggestions can be employed to influence the behavior and decision-making of individuals or groups. This framework has proven to be an effective and practical tool for promoting healthier eating habits in adults [13-14]. By simplifying the range of choices, thereby reducing the cognitive effort required for processing information, nudges can address the challenges faced by elderly individuals in terms of memory and task execution. Additionally, they can promote healthier behaviors and encourage an active lifestyle in aging individuals.

The possible future role of Big Data Analysis in seniors

Given the extensive amount of information that clinicians must consider, including personal histories, familial medical

3879

backgrounds, genomic data, medications, social media activity, and hospital admissions, guiding clinical decisions can become an overwhelming task. Analyzing big data using carefully designed statistical models and machine learning techniques can enhance the understanding and management of various clinical and sub-clinical conditions in the elderly. By gathering vital signs and detecting abnormalities, big data has significant potential in healthcare and plays a crucial role in monitoring the elderly for early health problem diagnosis [15].

FUNDING

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