Exploring the antecedents of adoption intention of smart healthcare technologies in rehabilitation process

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***Abstract*—The introduction of the Internet of Things and wearable technologies in a healthcare enables measurement of the user's vital parameters. The use of wearable devices in the process of rehabilitation, by doctors or therapists, should enable obtaining information about the psychophysical condition and progress of the patient. By applying the e-health services, the measured data are monitored, stored and analyzed. Based on the analytical results, appropriate methods and biofeedback can be created to improve the implementation of therapy and personalized preventive health messages for users. The main goal of this paper is to examine the antecedents of the adoption of smart healthcare technologies - IoT and wearable computing technology and health services among healthcare employees in the Clinic of rehabilitation Dr Miroslav Zotovic. An integrated adoption model based on TAM and TPB was proposed. The model is planned to be evaluated with about 90 respondents.**

Keywords—Smart healthcare, wearables, Internet of Things, rehabilitation, technology acceptance model

I. Introduction

With the development of modern and ubiquitous information technologies, there is a need to improve all aspects of electronic business, and thus the business of the healthcare area. Innovation in the healthcare system has led to the development of the concepts of e-health, mobile health, Internet of Things (IoT) and many others. These innovations have led to technical development, networking, and even the acquisition of positive habits and changes in the way employees and patients exchange, all with the aim of improving the quality of healthcare services[1]–[3].

The Internet of Things is a paradigm of modern society in which people and devices are connected and communicate with each other. We can also talk about the human dimension of the Internet of intelligent devices, and that dimension is present in the roles that the IoT has in the health sector.

Healthcare services, with intelligent devices and the application of the Internet of Things, open up new possibilities for improving healthcare, forming a new paradigm smart healthcare[1].

The smart healthcare concept is based on different technologies: mobile devices with mobile wireless communication, sensor technology, networking, big data analytics, cloud computing, wearable computing and the Internet of Things [4]. Given that, smart healthcare is an interdisciplinary field and with applied technological solutions and intelligent devices can improve the existing health system and respond to the challenges of modern health [5].

Such solutions can reliably and securely collect patient health data through a variety of sensors, apply complex algorithms to analyze measured data, and send it wirelessly to healthcare professionals. Based on the obtained health data, health experts will give patients appropriate health recommendations.

Intelligent devices in combination with other smart technologies are represented in all areas of health, but mostly in processes of monitoring vital parameters in real time, well-being, Ambient Assisted Living, in the field stress management, rehabilitation and many other areas.

The Internet of Things devices in the health sector enables the monitoring of certain vital parameters and the setting of goals for the improvement of users' health, which further has the task of increasing the user's motivation to achieve these goals.

Such devices with sensors that collect data from the user's body, can be built into clothing, watches, bracelets, glasses and the like. Such devices are called wearable devices and may include sensors for measuring: pulse, blood pressure, muscle activity, skin conductivity, respiration, then pressure sensors, temperature sensors, flow sensors, image sensors, accelerometer, biosensors, magnetoencephalography and magnetocardiography encoders [6] and others. In this way, wearable devices enable the collection of data on the psychophysical state of people. The aging and expansion of the population accelerates the development of new and different types of medical devices, as well as sensors used with devices [7]. In order to improve the comfort and safety of users, sensors are being developed that are reliable, easy to use and non-invasive.

Wearable computing in healthcare can be a technology for coping with demographic change. This technology can enable people to stay in their homes, with their families and perform daily activities. For the user, this means that he can do everyday routines, walk, socialize, engage in physical activities, study, read, sleep and perform all other activities, while his vital parameters are monitored all the time.

Collected, vital parameters are sent to physicians or other relevant health professionals in the fields of telemedicine, self-diagnostic systems, or predictive patient-oriented models for the health care system as biofeedback or for further analyses.

This reduces the possibility of errors, and at the same time increases the chances of accurate diagnosis because the vital parameters of the user measured by wearable devices would be available to the healthcare professional over a longer period of time. The measured parameters are more objective because they were measured in different life contexts, and not only in health care institutions.

There are numerous examples of realization of the IoT and wearable computing technologies, leveraged by smart healthcare, in different areas of healthcare [2].

Very frequent examples of using smart healthcare technologies is in physical rehabilitation, where it is most often used as an assistive technology for objective observation and monitoring of the rehabilitation process. In that area, the most common are motion sensors, in the form of gloves or T-shirts with sensors, all with the aim of objectively monitoring and recording the results after the performed activity. They are used in various conditions, in children and adults, e.g. in postural imbalance, after neurological deficits (conditions after surviving stroke), sports and activities in the elderly.

The paper [8] presents a set of smart gloves as a wearable device, which is used for natural interactions with therapeutic serious games for rehabilitation of the upper limbs. The data collected helps the physiotherapist to evaluate the treatment and effect of the therapy. The quality of the solution is based on the objectivity of measurement of motor activity parameters and especially the function of the upper and lower limbs during rehabilitation period. Patients' motivation is increased according the possibility of adequate feedback.

The study [9] presents ePhysio, a platform to for sensor-assisted physiotherapy and remote management of musculoskeletal diseases. The main goal was to monitor, stimulate, and encourage patient activity performance during self-rehabilitation. Experiment was performed with wearable sensor attached using a textile stripe to the wrist of the arm involved in the exercise. Evaluation proved that system can successfully collect real-time data from the patient and store it in the cloud system. Physiotherapist or doctor can monitor a rehabilitation in real time and have objective information about the patient's activity. Besides that, the evaluation of the solution showed great satisfaction with the project among health workers and users.

The authors of the study [10] propose a SoPhy wearable solution consisting of a pair of socks for the patient, with built-in sensors and a web application for displaying information on the movement and orientation of the feet in real time. The measured parameters are monitored by a physiotherapist via a web application, while the patient performs a certain activity on the therapist's instructions. The results of the evaluation showed that SoPhy increased self-confidence in the exercise process and that less repetition of exercises was required.

Smart healthcare technologies are not yet widespread and widely used, but in individual examples, in rehabilitation area, it can already be inferred that their use would have positive effects and be beneficial to healthcare professionals, health insurers, healthcare users and individuals [11].

Although these technologies may ultimately improve practice, there is relatively slow their adoption into physiotherapists day-to-day practice.

Employees are mostly accustomed to working according to the established regime with routine tasks, and often do not have enough confidence, awareness and trust in new technological solutions. There is often a fear of the unknown, limited access to services or lack of time to apply something new. Due to all the above, the path to the introduction of innovations and the daily application of new technological solutions is a great challenge.

Given the expansion of wearable technologies in living environment, and especially in the health care area, theories that predict and explain the factors influencing the adoption, acceptance and use of smart healthcare technologies are becoming increasingly important.

Certainly, there are numerous studies that are not focused exclusively on the quality of implemented information and communication solutions in health care, and one them is the Technology Acceptance Model (TAM) to predict the behavior and interpretation of end user reactions to a particular IT solution in healthcare system [12]. This model represents several factors that influence the decision on how and when users will use a particular technology, after it is presented to them:

- Perceived usefulness (PU) - by Davis [13] it is defined as "the degree to which a person believes that using a particular system will increase their work performance"
- Perceived ease-of-use (PEOU) - according to Davis' definition [13] is "the degree to which a person believes that the use of a particular system will be effortless"

In psychology, the Theory of Planned Behavior (TPB) is a theory that connects attitudes and behavior. This idea was proposed by Icek Ajzen [14]. The theory states that attitudes, subjective norms, and behavioral control together shape an individual's intended behavior. It is applied to the study of the relationship between beliefs, attitudes, intentions, and behaviors in various areas such as advertising, social relations, advertising campaigns, and healthcare.

Knowing the factors that determine the intentions of individuals, organizations are able to take advantage of these factors in order to promote the acceptance of IT innovations and increase their use in healthcare system.

Extant literature provides the understanding of how strength is users 'intention to adopt healthcare wearable technology and mainly refers to the acceptance test in patients or users [15][16][17][18][19][20][21].

There are examples of exploring the antecedents of adoption intention of mobile health [22], wearable technologies in healthcare [23] and also in rehabilitation process among physiotherapist [24] and clinician [25].

The aim of this paper is to examine the readiness for adoption of smart healthcare technologies as a part of rehabilitation therapy among employees in clinic for rehabilitation.

So, the research objectives are:

- provide an insight about antecedents of adoption intention of smart healthcare technologies,
- propose a research model to access antecedents of adoption intention of smart healthcare technologies,
- provide implications to healthcare managers, government and smart healthcare system vendors about perceptions of the experts in rehabilitation process

II. METHODOLOGY

We proposed smart healthcare technology adoption model, based on TAM [12], TPB [14], and theoretical model for healthcare [26]. The constructs of the research model were developed utilizing the theories within the literature. The model consists of six constructs, and five of them are antecedents of adoption intention of smart healthcare technologies. Construct Behavioral intention was redefined to Intention to adopt/use due to the nature of technologies that are not yet in use in clinic, and the future intention to accept them in practice is being examined.

The proposed model is shown on Fig 1. Intention to adopt/use (IU) [13] is a factor that leads people to adopt/use the smart healthcare technology. In this case, it is explained as a factor that expresses the readiness to accept Smart healthcare technologies. The (IU) is influenced by the Attitude (AT) which is the general impression of the technology. Perceived usefulness (PU) is a degree to which a person believes that using a particular system would enhance his or her job performance [13] and is hypothesized to be fundamental determinant of user intention acceptance.

Perceived easy of use (PEU) is the degree to which a person believes that using a particular system would be free of effort [13] and has an independent impact on PU and AT. Attitude towards the use of a smart healthcare technology is based on two main beliefs: PU and PEU. Accordingly, we derive hypotheses: Attitudes have a positive impact on Intention to use/adopt when it comes to use/adopt smart healthcare technology; Perceived ease of use has a positive impact on attitudes towards smart healthcare technology; Perceived ease of use has a positive impact on the Perceived usefulness.

Personal innovativeness (PI) presents the willingness of an individual to try out any new technology, and plays an important role in determining the outcomes of user acceptance of new technology or service. Those who possess inventiveness have the ability to include in their work something that is not already part of the existing system. PI is considered as an antecedent of AT and PEU.

Subjective norm (SN) [14] relates to a person's beliefs about whether people of importance to the person think he or she should engage in the intention behavior. SN is hypothesized to be determinant of user intention acceptance.

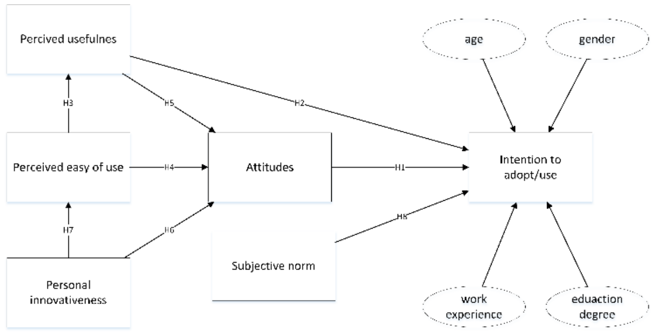

Fig. 1. Hypothesised smart healthcare technology adoption model

Finally, in the model, the intention toward adoption/use a smart healthcare technologies is determined by gender, age, experience and education.

Survey will be conducted with a structured questionnaire and it will be categorized in two sections. In the first section respondents will be informed about the purpose and the scope of the study. Also, respondents will be briefly introduced to the concept of IoT technologies, wearable devices and Smart healthcare services. Considering that these are experts employed in an eminent institution for rehabilitation, as well as the fact that there were examples of the implementation of systems based on IoT, we believe that the employees are to some extent familiar with the mentioned technologies.

In its final form, the five point Likert scale will be used to allow the individual to express how much they agree or disagree with a particular statement.

Second section are questions, clustered according to the factors that have an impact on Intention to adopt/use of smart healthcare technologies, namely: Perceived usefulness (5 questions), Attitudes (5 questions), Subjective norms (5 questions), Perceived ease of use (4 questions), Intention to adopt/use (4 questions), Personal innovativeness (5 questions). The selection of questions was made on the basis of studying the relevant literature, and modified in the spirit of the Serbian language.

The data will be collected using an online survey tool (Google questionaire). The group of the respondents will be drawn from an experts in the Clinic for rehabilitation Dr Miroslav Zotovic, Belgrade, Serbia, that is the most important and valuable clinic of its kind in the country. The target sample would be physiatrists, physiotherapists, orthopedists and other experts in the field of rehabilitation who are actively working in institution.

At the first step of analysis, descriptive statistics will be used to observe normality of the data.

To examine the appropriateness of the modified TAM model for our data set, we will use structural equation modeling based on partial least squares (PLS) using SmartPLS software. We opted for this software package because it is a desirable analytical tool for a small samples [27].

III. Results

The expected results will be a clearer identification of the antecedents and their impact on readiness to embrace smart healthcare technologies. Thus, it will be possible to highlight both barriers and advantages for accepting modern trends in healthcare.

The contribution of this research refers to the uniqueness of this type of research in the field of rehabilitation. Since the research will be conducted in an eminent rehabilitation institution, the results will be representative data for other institutions of a similar type.

The research will benefit managers of health institutions, distributors and IoT technologies vendors, as well as educational institutions that should innovate curricula when it comes to providing knowledge of IoT technologies in healthcare.

The development of a national questionnaire survey would provide exploring these issues in greater depth. The result of this study will be valuable to the researches, educators, rehabilitation practitioners, and smart healthcare vendors.

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