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Contextual Design of ICT for Physiotherapy: Toward Knowledge and Innovation Ecosystem

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Abstract

With advances in information and communication technologies (ICT), changes have been produced in physiotherapy provision. However, low adoption of the new technologies calls attention for better theoretical model and methods for ICT design, which may fulfil the needs of health professionals and their patients. In this work we discuss the framework for designing ICT for physiotherapy context based on some of the results obtained during research on requirements and barriers of electronic health records adoption in physiotherapy. We underscore the importance of considering the context - the conditions in social and physical environment as well as end-users internal conditions - for requirements elicitation of the healthcare information system. Identification, training and collaboration with champion/leader in the target community may contribute to creation and evolution of knowledge and innovation ecosystem for dynamic progress in designing and developing of ICT tailored to the people' needs, expectations and values.

Keywords: contextual design, information and communication technologies, online training, serious games, knowledge ecosystem.

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1. Introduction

Man-made ecosystems are defined as organizational designs that are held together on the condition that their members are in formal or informal agreement about shared purpose (baseline) and operation modes (logic of action) [1]. Although, in management studies, a primary motivation for utilizing ecosystem concepts has been the desire to exploit self-organizing properties of natural ecosystem [2], the man-made ecosystem is not entirely self-organized [1]. In this paper we describe a conceptual framework to design the information system for physiotherapy context, in which knowledge and innovation ecosystem should be built to facilitate the flow of knowledge and values as well as the interactions between the members of these ecosystems. Valkokari K. [1] characterized the differences between these two ecosystems as follow:

(i) the knowledge ecosystem (KE) have their main interest and outcome in creation of new knowledge while the innovation ecosystem (IE) focus on mechanism and policies fostering the creation of innovative start-ups around so-called regional hubs or cluster;
(ii) a large number of actors are grouped around knowledge exchange or central non-proprietary resource for the benefit of all actors in KE while in IE geographically proximate actors interact around hubs mainly by intermediating actors;
(iii) the actors in KE are the research institutes, innovators, and the technology entrepreneurs that

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serve as knowledge nodes while in IE, the actors are the innovation policymakers, local actors that intermediate the innovation, funding organizations, innovation brokers;

(iv) regarding the relationship and connectivity the KE is characterized by decentralized and distributed knowledge nodes, and synergies creation through knowledge exchange, while IE is characterized by different levels of collaboration and openness between geographically clustered actors;

(v) in KE the main focus is on exploration instead of exploitation of knowledge, while IE occurs as an integrating mechanism between the exploration of new knowledge and its exploitation for value co-creation in business ecosystem.

Example of knowledge ecosystem is *Wikipedia,* and Silicon Valley is an example of innovation ecosystem.

We describe the methods and tools that may be used for designing information and communication technologies (ICT) toward a knowledge and innovation ecosystem for physiotherapy context, based on our experience and results regarding the evaluation of requirements and barriers of electronic health records (EHRs) adoption in physiotherapy. Information and communication technologies are defined as a set of technologies that arise from information and advanced telecommunication and multi-media techniques which allow better communication means, information processing, storing, exchange and dissemination [3]. ICT stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless communication), Internet, multimedia, computers as well as necessary enterprise software, middleware, storage, and audio-visual systems, which enable users to access, store, process and communicate the data through various means: text, video, audio, human-machine interface, etc. The definition of EHRs continuously evolved in the last two decades, as the functionalities as well the observed problems are discovered. Recent definition have described the EHRs as "an electronic record of health-related information on an individual that conforms to nationally recognized interoperability standards and that can be created, managed, and consulted by authorized clinicians and staff across more than one health care organization" [4]. The electronic medical records (EMRs) system have similarities with EHRs but in this system the authorized clinicians and staff are only within one healthcare organization [4].

Given that each individual' or organizational' circumstance are different, a fixed, and/or a standardized pattern, or a top-down, "one-size-fit-all" design of healthcare information system does not fit well. More tailoring to the individual is necessary to match technologies for different unmet support needs. The paternalistic model that has prevailed in the past healthcare, in which the provider is often depicted as the guardian of the service user's best interests and is given the role of determining the approach to treatment [5], [6] is being changed. Generally, deliberative and partnering model of healthcare, model based on collaboration for co-production of health between users, their families and healthcare professionals, model that is more responsive to individual needs, model that incorporates individual perspectives and preferences in the care process, model that provide educational and psychosocial supports for an effective care partnership [7], [8], [9], are nowadays promoted. Dramatic changes are produced worldwide in healthcare provision through the instrumentality of ICT. A wealth of evidence suggests great potential of ICT to meet healthcare aspirations of patients and citizens [10]. In the last two decades various ICT were designed and implemented for improving healthcare services, for tailored and cost effective treatments. Our team had been involved in various projects related design and development of the technologies for low-cost, non-invasive, long term monitoring of human functional state. Particularly, in the last years the team had investigated: the knowledge and experiences on physiotherapists and patients' expectancies, perceived benefits and risks of EHRs; and the perspectives of Portuguese physiotherapists and their patients, on needs, requirements, and barriers for adoption of EHRs. The aim of the present work is to discuss some potential ways of designing new tools for physiotherapy process based on some of the results of the survey on the perspectives of physiotherapists and patients related to ICT for physiotherapy.

Physiotherapy, also known as physical therapy, or kinesiotherapy, has different definition [11] and worldwide the physiotherapists have various professionals' status. However, it is recognized that the core of expertise, practice, education and research in the physiotherapy is the assessment, prevention and treatment of movement disorders as well as functional autonomy promotion. Designing information system for physiotherapy services is a very complex work due not only to the diversity of environments in which physiotherapists provide healthcare services, and the complexity of competencies, skills and knowledge of physiotherapists - some overlapping with those of others health professionals (e.g., professionals for wound care, alternative therapy, occupational therapy) - but also to great diversity of the subjects receiving physiotherapy. Individuals that receive physiotherapy differ in terms of geographical locations, age, health, clinical history, functioning, disabilities and socioeconomic status [12].

Accurate, comprehensive information on the requirements and barriers for ICT adoption in physiotherapy may contribute to the development of effective, tailored to individuals' needs, and locally feasible solutions for healthcare information systems.

In the Methods section of the paper a brief description of methods that our team used for requirements elicitation related EHRs for physiotherapy is presented, and in section of Results and Discussion, based on some results of our work we discuss potential framework for ICT design that may improve physiotherapy processes.

2. Methods

Development of tools for improving healthcare services can draw on theory, evidence and/or practical issues. The team of the project EHR PHYSIO organized the work in three phases, aiming:

(vi) synthesis of knowledge and experiences on physiotherapists and patients expectancies, perceived benefits and risks related to EHRs;
(vii) evaluation of physiotherapists and their patients perspectives on needs, requirements, and barriers of EHRs adoption in physiotherapy;
(viii) physiotherapists and patients perspectives survey on EHRs for physiotherapy.

2.1. Phase One: Systematic Review of Knowledge and Experience Related Physiotherapists and Patients Perspectives on EHRs.

A literature review of books, research papers, journal articles, conference papers, theses and dissertation as well as reports from government, precedent projects was made to document international experiences regarding physiotherapists and their patients' perspectives on EHRs and ICT for healthcare systems. Comparative analysis and critical evaluation of existing design as well as of challenges related implementation and adoption of information systems for rehabilitation/physiotherapy context was carried out. Qualitative, quantitative and mixed-methods were used for content analysis of literature by using consensual guidelines for narrative synthesis and meta-analytical techniques in order to synthesize knowledge on perspectives of physiotherapists and patients related to: availability and use of ICT to support care delivery; features and performance expectancy of ICT for EHRs in physiotherapy; perceived benefits and barriers of adoption; behavioral intentions related EHRs. Inductive content analysis was used to establish the categories or codes from literature analysis. As key phrases emerge constituting a common theme, a name is given that characterizes the theme, and then subsequent examples of words or phrases that represent that theme are categorized accordingly, and used for subsequent analysis of all materials. Findings were organized using frameworks that propose conceptual model of physiotherapists and patients perceptions and needs related EHRs. Categories related to each other, in terms of content, were grouped into themes. The themes were then arranged according to the frequency of the underlying detailed problems. Content analysis was done manually as well as using NVivo software. After data were collected from physiotherapists and their patients through interviews, focus groups, workshops, contextual inquiry, a secondary research on scientific literature as well as on corporate and academic websites and blogs, and documented design projects was realized, to obtain more accurate information about characteristics that a EHRs system should have for physiotherapy context. We investigated particular characteristics of physiotherapy processes, strategies and ICT that are most likely to work in diverse local physiotherapy contexts. Secondary research was carried out to improve the knowledge on what has already been done, what hasn't, and the shortcomings that undermining the ability of people and organizations to implement information systems.

2.2. Phase Two: Patient-Physiotherapists-Designer Framework

Focus groups, brainstorming, semi-structured questionnaires, mind mapping were carried out during six workshops and three special sessions at international conferences. At every workshop participated physiotherapists, engineers specialized in biomedical instrumentation and measurements, and informatics. In each workshop the general goals of the EHRs for physiotherapy from both clinical and technical perspectives were presented. The key members of the project coordinate each 4-5 hours workshop by facilitating discussion about particular design goals and issues; system features and functionality. Tutorials and demonstrations of ICT with potential application in physiotherapy were also organized during workshops/special sessions. Physiotherapists networking activity was also promoted. A semi-structured style of interview was realized with open questions, in order to stimulate the interviews, and receive detailed opinions, experiences, and descriptions of needs related with the daily living/work routine. Participants were included in focus group using snowball sampling, based on referrals from physiotherapists and caregivers. Interviewers used a semi-structured interview guide to ensure that similar questions and themes were addressed in all interviews. However, interviewers were free to adapt the questions, probe responses, and follow respondent-driven topics. Questions were developed before conducting interviews using a conceptual model of physiotherapists and patients perspectives derived from content analysis of literature (phase one). Interviews with physiotherapists were realized during workshops. Interviews with patients were realized at physiotherapy clinics and lasted 30-120 minutes. Content analysis was conducted also on the transcriptions of interviews. Mind maps were created, by using method described by Tony Buzan [13] and iMindMap software, until information on requirements and barriers for adoption of EHRs in physiotherapy were easily described using imagine of relationships between categories and themes that were extracted by content analysis of the notes, photographs, drawings from workshops and conferences, and also transcripts of the interviews. Tree diagrams were realized to describe hierarchy, or relationships between main and supporting ideas derived from content analysis. Interviews' transcripts were analyzed thematically, by three

researchers, using the immersion/crystallization approach, which emphasizes gaining an in-depth knowledge of the data, in order to identify key themes. Data collection and analysis were conducted sequentially. The team drafted a coding scheme based on the conceptual model, discussion of findings, and initial impressions from the data.

2.3. Phase Three: Survey of Physiotherapists and Patients Perspectives Related EHRs for Physiotherapy

Based on data from literature review, workshops, interviews and secondary research two questionnaires were developed. Four pilot tests for validation of the questionnaire *Inventory of Physiotherapists Perspectives related with EHRs* were realized, one using experts in physiotherapy (n=7), physiatry (n=1), and psychology (n=2). Two tests for validation were realized for the questionnaire for *Inventory of the Patients Perspectives on Information and Communication Technology*. Convenience sampling was used for data collection related the perspectives of physiotherapists and patients on EHRs for physiotherapy. The questionnaire designed to study physiotherapists' perspectives on EHRs for physiotherapy, which consist of 27 questions, was self-administered and accessible online from December 2014 and September 2015. The questionnaire designed to evaluate the perspectives of patients on ICT for physiotherapy, have 42 questions, and can be administered with support of other person (in our study with the help of psychologists that worked in EHR PHYSIO Project team) or self-administered. Research concerning the ways for increasing patients' participation in this study was carried out. Vouchers, flyers with information on projects, and online link to the questionnaires were distributed. The questionnaire for patients was also available online from December 2014 to September 2015. For some patients [n=266, mean(SD) age: 55.3(±18.1); 58.3% female; 31.5% with rural residence] functional status of the patients was measured by using Health Utilities Index (HUI). The HUI3 attributes include vision, hearing, speech, ambulation, dexterity, emotion, cognition, pain and discomfort. Statistical analysis was conducted using SPSS to account for the complex sample design of the survey.

2.4. Developing and Pilot Testing of a System for EHRs for Physiotherapy

Scenarios on workflow of physiotherapists' interventions were discussed and system architecture for EHRs for physiotherapists based on mobile technologies, wireless sensors networks, M2M, Serious Game and natural user interface have been designed, particularly for movement deficiency diagnosis and monitoring, for remote monitoring of physiotherapy interventions, and in-home exercises training. A range of potential ICT for physiotherapy was considered in parallel prototyping process. This method enables the research team to experiment with and investigate the technological and technical characteristics of various mobile technologies for patient-centered healthcare information system. Informatics and engineers collaborating on parallel prototyping often merge and refine others concepts into their subsequent designs. The prototypes as well as various free applications, for smartphone and tablets, with potential use in physiotherapy processes, were tested by the research team during the project time interval as well as by physiotherapists during workshops. Rapid iterative testing and evaluation (RITE) of prototypes and software applications, was done during the project development. The method allows early identification and removal of the biggest problems related the features of the prototypes, before time and resources are spent producing a high-fidelity prototype as well as strategies creation for better design solutions. No usability reports were written during RITE. The updated prototypes were tested as the new design direction. Evaluative research of health information system for patient receiving physiotherapy was carried out, in September 2015, in two physiotherapy clinics, by two physiotherapists and 20 patients, involving the testing of prototype and interface (developed by our research team). The goal was to collect feedback from end-users if the developed system is useful, usable, and desirable.

2. Results and Discussions

An evaluation of the physiotherapists' and their patient's needs related ICT for physiotherapy process and barriers of ICT adoption was carried out, mainly based on evidence based research. Evidence-based research was used:

(i) for requirements elicitation for EHRs system for physiotherapy, based on high level of evidence related to benefits and effectiveness of the implemented ITC in other healthcare areas in Portugal or in physiotherapy or other healthcare areas in other countries (i.e. by content analysis and conceptual mapping of scientific literature or relevant reports);
(ii) to inform on strategies for designing healthcare information system for physiotherapy context;
(iii) to design hypothesis on requirements of ICT for patients receiving physiotherapy, that are linked to the desired physiotherapy outcomes;
(iv) evaluative research of ICT for physiotherapy and of the models, prototypes, and interfaces developed by our team.

A scoring system for identification of high level of evidence related ICT for physiotherapy context was developed by our team [12] taking into account GRADE - Grading of Recommendations Assessment, Development and Evaluation (www.gradeworkinggroup.org), and RE-

AIM - Reach, Effectiveness, Adoption, Implementation and Maintenance [14] guidelines. Although the expertise and statistical data are important for any complex or large-scale information system development, we consider that this information alone do not yield comprehensive information on local needs, values and attitudes of physiotherapists and the subjects receiving physiotherapy related ICT. Therefore, triangulation of data from multiple sources was carried out to obtain a rich depth and accurate information related the requirements and barriers of adoption of ICT in physiotherapy (see Fig.1).

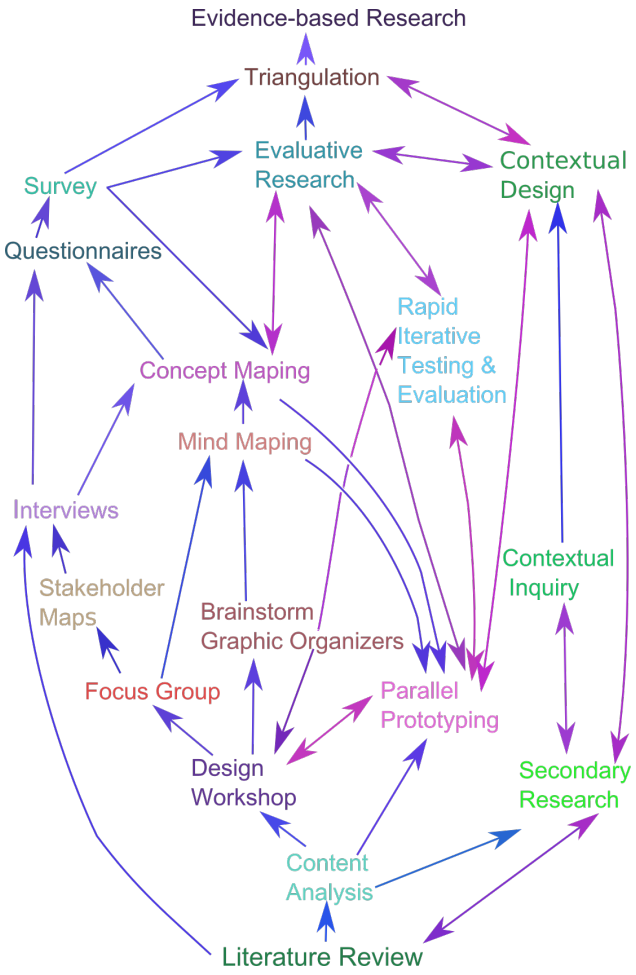


Figure 1. Methods for the design of the information system for physiotherapy.

Data from literature review was combined and critically analyzed with data collected during workshops, conferences, interviews, contextual inquiry and physiotherapists' and patients' survey on perspectives related ICT for physiotherapy. Through this complex process various shortcomings were identified in the methods that the team used, and potential solutions for overcoming these, and to improve the process of designing complex information system, tailored to end-user needs were identified. Following we described the framework based on results of the physiotherapists and patients survey related perspectives on ICT for physiotherapy, in which potential of ICT might be used for better requirements elicitation related to healthcare information system, particularly EHRs for physiotherapy.

Rich information was extracted from physiotherapists that participated at 6 workshops - average and range 29 (15-50) participants, and more 180 physiotherapists that responded at our developed questionnaire that was online administered. Also, for EHRs for physiotherapy' requirements elicitation the information from interviews with 20 patients (when the developed questionnaire was tested) as well as data from 366 patients' survey on perspectives on ICT for physiotherapy were used.

As can be shown in Fig. 1 the main domain of intervention of the physiotherapists that participated in our survey is related with movement disorders.

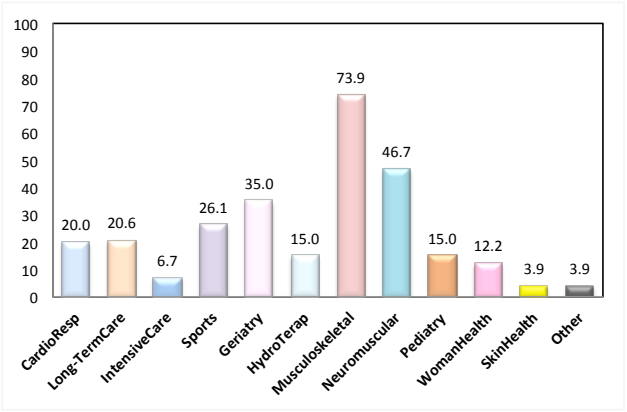


Figure 2. Domains of interventions and percentage of physiotherapists who participated at survey.

They can act in hospital or clinics but also in other healthcare institutions, social institutions, sports club, beauty office, etc. (see Fig. 2). Therefore the information that they would like to store, process or share with their patients or to other professionals is very diverse. Although a lot of information was collected during workshops and surveys, the general feeling of researchers of the project EHR PHYSIO is that requirements elicitation for information system for physiotherapy may lead to technologies with missing important and necessary functions for some physiotherapists and for other physiotherapists to many, unnecessary features, depending on their area of intervention, their skills, their patients' needs and workplace environments. Based on our research we suggest that for better requirements elicitations, discussions in groups of physiotherapists with high level of similarity in practice should be organized. Low time availability for meetings organization, for discussion of the needs and barriers of implementation of EHRs for physiotherapy, as well as geographical distance and lack of financial support were the main reasons for

low physiotherapists' participation in organized events for requirements elicitation.

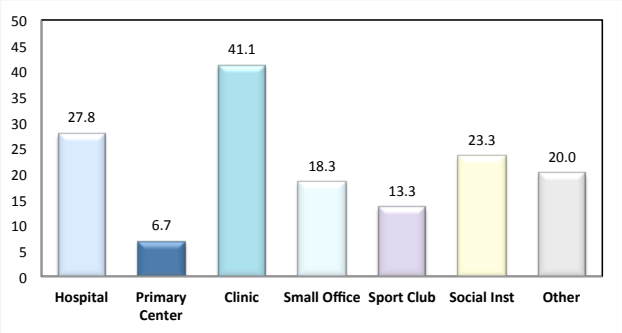


Figure 3. Workplace and percentage of physiotherapists who participated at survey.

Moreover, difficulty of physiotherapists and their patients to comprehensively describe their needs and the process of interventions as well as properly understanding of physiotherapy processes by the engineers and informatics had induced a high level of uncertainty in defining system boundaries and in producing a consistent and complete set of software requirements to be implemented. Data from the interviews realized during the research project, as well as evidence from the social research from Portugal [15], [16], [17] had underscored that low health and digital literacy of patients could be important factors that might reduce comprehensive drawing of requirements for information system for physiotherapy. In our view, software tools developed and available for free or at very low pricing could be used for better ITC for physiotherapy requirements elicitation. For instance, applications that allow sharing documents and messages as Evernote, Google Drive, Slack, Ryver might facilitate:

(i) heavy documentation, wikis, videoconferencing, etc;
(ii) collaboration, knowledge transfer between stakeholders;
(iii) effective informal communications between physiotherapists with similarity in practice and ITC developers;
(iv) identification and addition of more requirements in the following discussion;
(v) and more effective identifications of needs and expectations.

A method for improving requirements elicitation, particularly for the groups working in diverse and complex environments, was described recently [18]. The work suggests that serious games developed by Innovation Games® might be used for practicing teamwork, improving interaction between participants, and increase quantity and quality of requirements for ICT development. For example, in the game *Prune the Product Tree* the participants should collaborate to shape the desired product in the form of a tree (i.e. system functionalities – as limbs; system features – as fruits; the root system as trunk). A short description for each feature should be written on an index card, which represents a fruit or a leaf, and the card should be placed on the tree. The leaves or fruits closer to the trunk indicate requirements with higher priorities, which should be delivered as soon as possible. The online version of the game consists of the game area, a chat and whisper facility, and a palette of items (e.g., fruit, leaves, index cards). While participants are describing their expectations, other players have the opportunity to ask questions and discuss features and their priorities. The requirements can be reformulated and the development team can analyse the requirements of the system to be developed based on the descriptions provided for each feature, and the discussions recorded between the participants. The participation to online serious game for requirements elicitation for developing ICT for physiotherapy might engage physiotherapists and their patients in developing ICT tailored to their needs and expectations. Moreover, online serious games enable the development teams to collaborate with physiotherapists and their patients from diverse workplace, without limitations of time and geography and to easily collect new ideas and quick feedback for creating precise project roadmaps. Furthermore, serious game might be used as a catalyst for discussion and negotiation between end-users and developers, and a playful method for drawing and resolving requirements conflicts.

In the first workshop, brainstorming, focus group and mind mapping was scheduled. Large poster paper, writing materials, sticker paper, scissors, and tape were collocated on the room tables. Six drawing board were distributed in the workshop room. The participants had received written instructions on mind mapping method. A brief description of brainstorming process, (taking into account the assumption that majority of the participants have good knowledge on this method) was made by one member of research team. 'Build on each other's ideas', 'go for quantity over quality', 'push beyond the limits of what seems possible' 'withhold judgment and criticism' and 'welcome oddity' are a few of the widely accepted rules of brainstorming [19]. Brainstorming method is mainly used to create a safe forum for the expression and free association of creative ideas in a judgment-free environment. However, when the method is not correctly put in practice no meaningful outcome might be obtained. The participants were allowed to choose the group for discussion on needs and barriers of adoption of EHRs in physiotherapy. Only, some photos were made as research team considered that video capturing of the workshops will produced participant discomfort. Groups were formed with 5-6 members and groups with 8-10 members. In the brainstorming session organized by our team very low participation at discussions was observed. Certain participants have a seat at the table, but have little or no voice, and other participants with higher level of communication skills and on professional hierarchy,

dominate the discussion. In our view this was produced by various factors: cultural determinants and personality traits of the participants and no adequate planning of the brainstorming process by the staff members. Groups with only 4-6 members should be allowed – more ideas were registered from small group. The main personality traits of therapists should be considered in organization of brainstorming session. Generally, the therapists are characterized by conscientiousness and agreeableness. They show self-discipline, act dutifully and have tendency to be well organized and dependable, and to have decisions guided by rules, laws and principles, they are kind, generous, and trustworthy. However, they have a preference for more planned rather spontaneous behavior and this personality trait is more salient with age advance. Therefore, strategies should be defined before brainstorming session to create an environment that engages the participants in the discussions. The research team should create opportunities for each person to speak, to write ideas and to see others written ideas, to encourage participants communicate their ideas in ways that are most comfortable for them, for example, through storytelling or drawings. The research team should ensure the presence of a skilled moderator for each group to ensure that everyone involved in the process participates on an equal footing regardless of their position in the professional and social hierarchy, and to create an environment where the fear of being judged is diminished, and in which the participants feel comfortable expressing different opinions, present new ideas, and raising questions. Also as many words have different meaning to different people the moderator should not allow any individual or small group to reinterpret and refine the ideas that the group had produced. The requirements elicitation based on wrong assumptions on meaning might bias the model development. To ensure that the right meaning of expressed participants' opinion is registered the video capture is often employed in brainstorming session. Advance in ICT might contribute for better management of the session by capturing the image of each group with small 360° video cameras (i.e. Nokia, Samsung, Nikon 360° camera). Algorithm might be developed to facilitate the work of moderators and research team in the brainstorming session (i.e. annotation of the events, notification). Increase success of interventions of the moderators might be produced by rapid and comfortable evaluations of cultural dimensions during formal and informal presentation of the participants. The five cultural dimensions identified by Hofstede G [20], [21] in his research with IBM employees from 53 countries might be used:

(i) Power Distance: the extent to which the less powerful members of groups or categories expect and accept that power is distributed unequally;
(ii) Individualism/Collectivism: the extent to which the ties between individuals are loose/tight;
(iii) Masculinity/Femininity: the extent to which social gender roles are distinct/overlap;
(iv) Uncertainty Avoidance: the extent to which the members of groups or categories feel threatened by uncertain or unknown situations;
(v) Long-/Short-term Orientation: the extent to which virtues are oriented towards the future/the past and present.

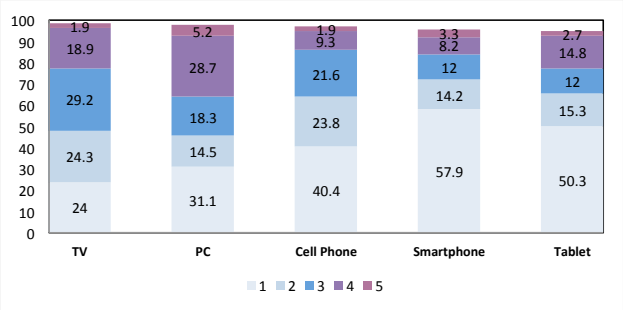
The moderator should manage the group discussion so cultural dimensions did not compromise the integrity of the collaborative process.

The method of mind mapping allows visually organizing a problem space in order to better understand it. Although the participants receive written instruction for mind mapping, participants did not use the instructions during any workshop session and no relevant mind mapping was collected from participants. We used mind mapping for organizing the data collected during workshops for better understanding and enhance recall of a problem space. A central theme was defined and the issues related with this central theme were drawn outward from the center of the map, taking into account the importance of the issue and his meaning. The process of making free associations should continue until all relevant pieces of information related with central theme are represented. We consider that moderators of group discussion should support individuals and group in mind mapping process, as this tool might provide a means to visually represent the different ways that people prioritize and organize information as well as this might contribute for creating new knowledge.

ICT may also be used for engaging people in mind mapping. Software applications for computer based mind mapping can be found through web search (i.e. iMindMap, XMind, Coggle, Popplet). The mind mapping software combined with whiteboard technology (i.e. Smart Board 880), or interactive projectors technology (i.e. TouchJet Pound Projector or Sony Xperia Touch Projector that turn any flat surface into a supersized touch screen), or smart TV (i.e. Smart TV 3D Samsung 79) may contribute for engagement of participants in collaborative design process as well as more efficient mind mapping process. For example, by using drawing board or poster paper there are situations when new ideas is not possible to be included in the desired position as no more space are available. With the above mentioned technologies, creating new space for mind mapping is very easy. Moreover, the technologies allow realization of more meaningful mind mapping as rapid search of images or different information might be obtained through Internet search.

In the selection of theory and practice, informed requirements, mapping of present infrastructure into its' theoretical determinant' should be carried out, in order to identify potential levers for change. This evaluation should also take into account the likelihood of resulting a product and service from a combinations of any of the components or the behaviors of the system. In our research project we investigate the ICT that physiotherapists or patients already have, frequency of

use, as well as determinants of their use. At the question on importance that is given to use of technologies for their physiotherapy process, the patients indicated as more important for future development the personal computer, Internet, and technologies that allow in home physiotherapy through online training with physiotherapists (see Fig. 4, Likert scale 4-5). Assessment was made using Likert scale (1 to 5; 1-no importance; 5-very important). Percentage was calculated for all samples (the difference between sum of respondents and 100% are represented by missing data, as respondents were able to choose the items for each they wanted to give an input).



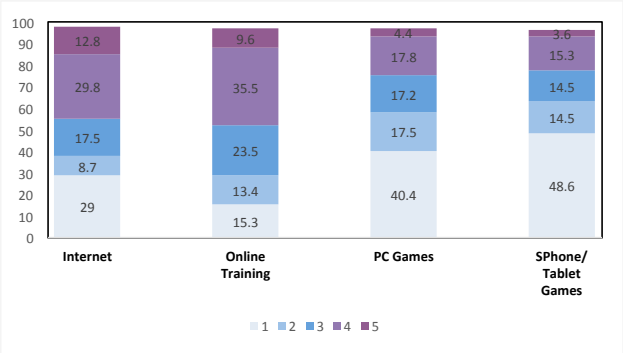


Figure 4. Perceived importance of technologies in future development of physiotherapy.

These data should be analysed in the context of present use and frequency of use of these technologies. At the questions 'what technologies you have or had' and 'in the last year, what the frequency of use of technologies' the patients indicate TV and Internet with more frequency of use (Fig. 5 and Fig. 6). In 2016 in Portugal more than 80% of persons, with age in range 16 to 74 years, have used Internet through different equipment [23]. The results of our study is in line with population assessment from 2016 that showed that less than 60 % of Portuguese use frequently Internet, and approximately half of population did not use computer or tablet [23], [24]. As the access to ICTs and to Media defines the dimension of digital divide [25], the results from our study suggest high dimension of digital divide, mainly in rural elderly [26]. Effects of ageing such as hearing, sight, cognitive and motor impairments, combined with lack of experience of elderly with new technologies (like personal computers, smartphones or tablets) may explained the differences of ICT adoption in elderly population. Different strategies should be envisioned to reach the hard to reach patients, taking into account that the benefits of ICT for improving healthcare services [27] may be higher for the patients from remote regions (e.g., from rural areas), or patients with low level of education [28]. The increase in adoption rate may allow patients to look at and analyse their medical information or to enquire on their treatment processes.

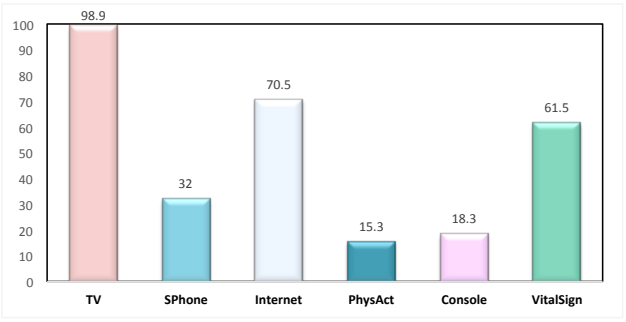


Figure 5. Percentage of patients that have or had information and communication technologies.

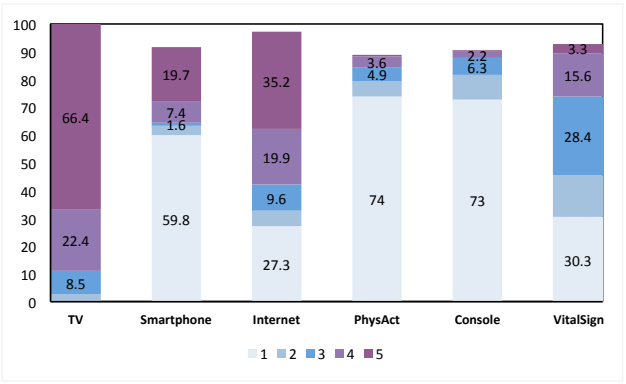


Figure 6. Percentage of patients that reported use of technologies and perceived frequency of use.

The more use of devices for vital signs monitoring (i.e. device for heart rate or blood pressure monitoring) in comparison with those for physical activity assessment and monitoring, suggests the influence of social determinants such as:

(i) social validation – individuals are more likely to engage in behaviors who they perceived others are also engaged, and signal their conformity, in that they have also engaged in some behaviors [22], [29], [30];

(ii) social comparison - individuals evaluate their own opinions and abilities by comparing themselves to others in order to reduce uncertainty in these domains, and learn how to define the self [31];

(iii) health literacy – although different studies had shown low level of health literacy in Portugal [16], [17], a greater group of participants that use vital signs monitoring devices compared with those for monitoring physical activity may be explained by various educational and health preventive programs that were organized in Portugal, in the last years, in order to raise awareness on potential of using devices for vital signs monitoring for prevention and disease adoption in physiotherapy.

Therefore, to increase adoption of devices for physical activity monitoring, and for effective design and implementation of the physiotherapy intervention based on developed ICT, the key may be the incorporation of the conditions from social and physical environment as well as the end-user internal conditions that are needed to be in place for a specific physiotherapy process.

The physiotherapists that participated in our survey reported using as main source of information based on ICT, for physiotherapy process, the software for administrative management and information from Web sites (see Fig. 7).

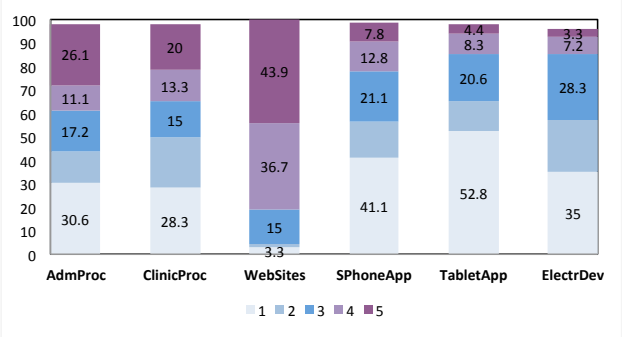


Figure 7. Percentage of physiotherapists that reported use of technologies.

Assessment was made using Likert scale (1 to 5; 1-no use; 5-always use). Percentage was calculated for all sample (the difference between sum of respondents and 100% are represented by missing data, as respondents were able to choose the items for each they wanted to give an input). However, they reported that they would like to have access to technologies for clinical process and electronic devices that should improve assessment and monitoring of physiotherapy intervention (see Fig. 8).

Physiotherapists are aware on increasing evidence that electronic devices in combination with virtual reality may improve physiotherapy intervention (i.e. balance training, posture and coordination training, biofeedback, stroke rehabilitation, cardiac rehabilitation, etc.) [12]. In the last years, electronic devices have been developed for integration in Internet of Things (IoT) technologies with potential for improving physiotherapy process. Technology for exergame with near-realistic motions based on body-wearable sensors was described [32]. An innovative, computer-based gaming platform based on instrumentation with a motion-sense mouse, which should transform broad range of common objects into therapeutic input devices, was designed and it is being evaluated [33]. By using this technology, algorithm based on acquired movements that replicate common situation in everyday living, can be used for designing serious games.

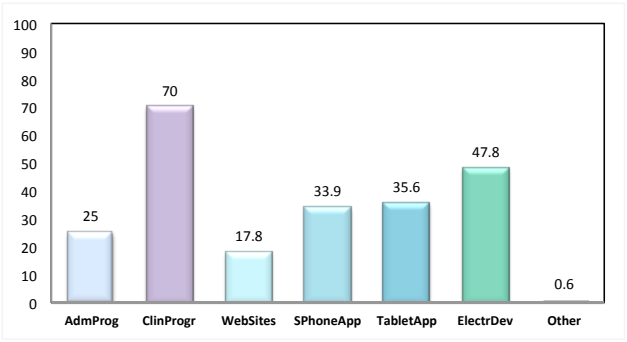


Figure 8. Percentage of physiotherapists that indicate what they would like to use in physiotherapy practice.

Many software for rehabilitation management including virtual reality, augmented reality or serious games were developed and some are commercially available (i.e. MIRARehab, BioGaming, exergames based on Nintendo Wii ™ technology, Xbox Kinect technology, applications for smartphone, tablet or TV from GooglePlay, iTunes or APTOiDE). Visual, and/or audio, and/or haptic (interaction involving touch) interaction, and/or immersive (providing information or stimulation for a number of senses, not only sight and sound, that deeply involve one's senses and may change mental state), simulation of real, imaginary or symbolic environment, was developed, with objective of improving rehabilitation or other physiotherapy processes. Examples of ICT tools used or with potential use for physiotherapy are BioGaming apps, MIRARehab apps, YouRehab apps, CoRehab apps, I Am a Dolphin apps developed by John Hopkins Hospital, PocketPhysio, Hand Rehab, Button Board apps for smartphone, apps/games based on Nintendo Wii, Xbox Kinect, PlayStation technologies. The developed software for Augmedix healthcare service, or Kinesio Capture apps for smartphone use augmented reality. Windows Holographyc developed by Microsoft that use mixed reality (a mix of the physical and virtual reality, by merging the real and virtual worlds to produce new environments and visualizations, where physical and digital objects co-exist and interact in real time) may also be used in physiotherapy. Various interfaces were

developed for interaction with virtual reality – Leap Motion, Microsoft Kinect, Nimble from Intugine Technologies, Wii Remote, Wii Balance Board, iKids Interactive Zone, Gloveone, Fit Interactive's fitness system 3 Kick, Virtuix Omni, Oculos Rift, Samsung Gear VR, ZSpace, Google Cardboard, Epson Moverio BT-200, Microsoft Hololens).

With developing ICT a new category of patients is also developed. e-Patients, coined by Tom Ferguson in 2007, are those patients equipped, enabled, empowered and engaged in their health and health care decisions. PatientLikeMe, BrainTalk Communities, NeuroTalk are e-Patients social networks. The importance of e-Patients as consumer, curators and creators of information, are recently recognized and investigated. e-Patient potential for improving quality of care may be analysed and should be considered in ICT tools for physiotherapy.

An increase in the gap between development of ICT and healthcare services progress are often reported in the last years. In many studies low adoption of these technologies in healthcare services are reported, and in physiotherapy processes in a lower degree. The physiotherapists participants in our survey indicated various barriers for the adoption of ICT in physiotherapy, mainly those related to: lack of financial incentive for ICT implementation; lack of knowledge on physiotherapy processes and workflow by information system developers; not acceptable technological performance; costs of implementation and maintenance; not addressing tangible and practical needs; regulatory policy; lack of public institutions' support for implementation; lack of cooperation between physiotherapists and ICT developers [34]. These results suggests the necessity for better theoretical model for designing and for ICT implementation, in which policy interventions – service provision, regulation, legislation, environmental and social planning, communication/marketing, guidelines, fiscal measures - should be considered together with motivation, and capability of all stakeholders, as well as opportunities created by training, education and incentivisation.

In our view training of health professionals for active involvement in designing and implementation of ICT tools should be an important goal of healthcare service providers and universities. In the last decade increase number of evidence indicate that stakeholders' training and education are key to successful adoption of ICT [35]. Moreover, it was suggested that health professional (i.e. physiotherapists) with expertise in informatics can help design systems that meet the needs of physiotherapy, and rigorously evaluate the extent to which they actually improve care [36]. Majority of the physiotherapists that participated in our survey reported low and very low level of knowledge on ICT (see Fig. 9).

One solution for training of therapists in ICTs would be organization of online database, similar to HELM open database developed by University of Nottingham, in which free to use high quality interactive peer-reviewed learning and teaching resources related with ICT for physiotherapy may be found. Also, activities that incentive the physiotherapists to work with software for storyboarding (e.g., StoryBoardThat, Google SketchUp), software for ease creation of mobile apps (e.g., AppInventor), software for easy serious game design (e.g., Scratch, GameMaker, GameGuru, ItyStudio, Unreal Engine, Unity – Game Engine) may contribute for better design of ICT tools for physiotherapy. Open interfaces make easy for developers to innovate and proliferate and pave the way for rapid exploration and innovation in the sector.

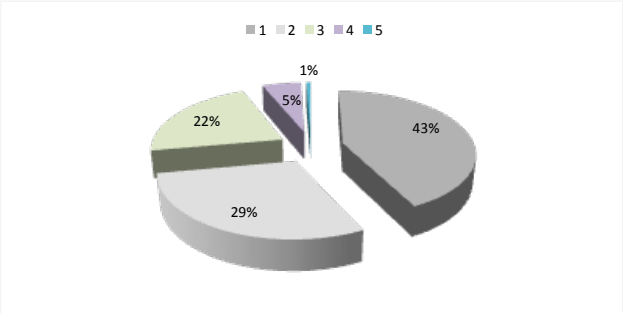


Figure 9. Percentage of physiotherapists that reported level of information and communication technologies knowledge. Assessment was made by using Likert scale (1 to 5; 1-very low level; 5-very good level).

The presence of a champion, someone who is the leader for an information technology project, was also identified as a critical factor in successful implementation of ICT - "Health care providers' readiness is connected to baseline levels of computer knowledge" [37]. In their very informative study Kaye et al. [38] has shown "When health IT was in its early stages, we needed doctors who had a knack for computers to help the IT people build 'doctor-friendly' systems. Today, we have a growing cadre of doctors who have made medical informatics their profession. These professionals are an important bridge between the practicing physician who is not equipped to explain to the technician what he really needs; the manager, with his concerns and system objectives; and the technological people with their ever-expanding bag of IT goodies. We need to encourage increased professional leadership in this area to help systems make intelligent decisions about continued innovation". The champion or leadership may contribute both for better requirements elicitation for health or healthcare information system as well for developing the knowledge and innovation ecosystems.

Beside planning the timing and logistics appropriately, the research team involved in designing and developing of ICT should investigate the 'early adopters' (who are willing to take risks of new technology adoption and that often are 'opinion leaders' [39], [40] who are watched by others [41] and 'innovators' (the first one that adopt a new

innovation) with good communication skills and personality trait (i.e., more openness to experience – those that appreciate new experiences and stimulation due to being imaginative, creative, emotionally as well as aesthetically sensitive) [42] in their target community and establish collaboration for engagement of diverse participants in meaningful discourse for KE and IE realization. Research should be done to identify the optimal skills that champion or leader should have, or should be trained to have positive impact on focus group and on the larger community, or to increase effectiveness of the creation and evolution of KE and IE. KE and IE should increase the efficacy by combination of subjects' knowledge, skills, and resources and may contribute to dynamic knowledge creation and innovation.

The researchers and identified champion/leader should continually establish relationships with individuals and organizations who will benefit from the project, and also with those who hold power, to make people aware of the benefits of ICT and to optimize the ways health professionals and patients are involved in designing and developing ICT. Also, through these collaboration a comprehensive stakeholders mapping should be realized in order to better understand who are interested in the project development, who will benefits as well as who may be adversely affected and even those who may thwart the developed ICT.

KE and IE may promote critical thinking, which helps people develop a healthy skepticism, skills in weighing information, and sensitivity to fresh ideas and perspectives necessary for dynamic progress on designing and developing of ICT tailored to people needs, expectations and values.

4. Conclusions

There is a trend toward physiotherapy interventions combined with emerging ICT. The conceptual framework of requirements elicitations developed in project EHR PHYSIO research project, together with suggestions derived from our results and our recommendation on ICT may be used for tailored ICT tools for physiotherapists' practice and patients' needs. Rigorous and tailored design of the physiotherapy service incorporating ICT may lead to operational improvement and positive program outcome, augmented physiotherapist-patient relationships, autonomy and engagement of patients in regards to their healthcare, better quality of service and cost-effectiveness of intervention. Training physiotherapists, informal caregivers and patients, to raise awareness and knowledge on ICT would greatly contribute for better physiotherapy services and improve quality of life of patients. Collaboration is need (between public authorities, ICT providers, associations of physiotherapists and other health professionals, patients' organizations, reimbursement scheme providers, insurer, medical devices and information technology regulatory organizations) for integration of ICT in physiotherapy practice.

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