Designing Digital Tools for Physiotherapy

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Abstract. With advances in information and communication technologies (ICT), dramatic changes have been produced in physiotherapy provision. However, low adoption of the developed technologies calls attention for better theoretical model and methods for ICT design, which may fulfill the needs of physiotherapists and their patients. In this work we discuss the framework of designing ICT for physiotherapy based on some results obtained from the perspectives of physiotherapists and patients on electronic health records for physiotherapy. We underscore the importance of considering the context - the conditions in social and physical environment as well as end-users internal conditions to be in place - for a specific physiotherapy process.

Keywords: Context based design · Online training · Serious games

1 Introduction

Ageing populations, change of illness pattern into an increase prevalence of non-communicable diseases in all population age groups, technological developments and new patterns of practice and funding techniques in healthcare systems, are altering the way healthcare is delivered by providers and accessed by service users. The quality of life and wellness are the main goals of healthcare systems in the 21st century medicine. Healthcare system reforms are promoted worldwide, leading to a medicine that is preventive, predictive, personalized and participatory [1].

Given that each individual's circumstances are varied, a fixed, and/or standardized pattern of provision by each healthcare organization 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 health care, 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 [2, 3] is being changed. Deliberative and partnering model of healthcare, model based on collaboration for co-production of health between user, their families and health care 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 [4–6] are nowadays promoted worldwide.

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Nowadays, dramatic changes are produced worldwide in health care provision through the instrumentality of information and communication technologies (ICT). A wealth of evidence suggests great potential of ICT to meet healthcare aspirations of patients and citizens [7]. In the last two decades various ICT were designed and implemented for improving health care services, for tailored and cost effective treatments. Our team had been involved in various projects related designing and development of the technologies for low-cost, non-invasive, long term monitoring of functional state. Particularly, in the last years the team had investigated: international knowledge and experiences on physiotherapists and patients expectancies, perceived benefits and risks of electronic health records (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 ICT for physiotherapy.

Physiotherapy, also known as physical therapy, or kinesitherapy, has different definition [8] and physiotherapists have various professionals' status worldwide. 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. In Portugal, physiotherapists promote and in some cases also prescribe physical activity programs in the area of prevention, maintenance, and treatment. They provide care for the premature babies; care for the children with impaired motor functionalities; rehabilitation of cardiac and respiratory system; therapy for musculo-skeletal disorders; programs for preventions of functional decline in older adults, etc. Physiotherapists can practice in hospital, primary health centers, private clinics, community centers, etc., either alone or in different teams. 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 having physiotherapy differ in terms of geographical locations, age, health, clinical history, functioning, disabilities and socioeconomic status.

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

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:

1. synthesis of international knowledge and experiences on physiotherapists and patients expectancies, perceived benefits and risks of EHRs;

2. evaluation of the perspectives of physiotherapists and their patients on needs, requirements, and barriers for adoption of EHRs for physiotherapy Patient – Physiotherapists – Designer Framework;
3. physiotherapists and patients perspectives survey on EHRs for physiotherapy.

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

A systematic review of the scientific literature (qualitative, quantitative and mixed-methods studies) and other published documentation (technical or grey literature) was carried out to document international experiences regarding physiotherapists and their patients perspectives on EHRs and ICT for healthcare systems in order to synthesize knowledge on perceptions of physiotherapists and patients related: 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 electronic health records. Standardized literature was conducted in all relevant databases. Meta-analysis of the published documents on the status, success and documented problem, achievement of goals, strengths and weaknesses of the implemented EHRs and ICT for physiotherapy was conducted. The detailed problems were abstracted as far as possible, for the purpose of summarizing them into categories. This was done by using consensual guidelines for narrative synthesis and meta-analytical techniques. 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 critical areas. The critical areas were then arranged according to the frequency of the underlying detailed problems.

2.2 Phase Two: Patient-Physiotherapists-Designer Framework

Focus groups, brainstorming, semi-structured questionnaire, 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 h workshop by facilitating discussion about particular design goals and issues; system features and functionality. Tutorials and demonstration 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 for providing 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 patients perspectives derived from review of the literature (phase one). Interviews lasted 30–120 min. Content analysis was conducted on the transcriptions. Mindmaps were created, by using method described by Buzan [9] and iMindMap software, until information on requirements and barriers for adoption of EHRs in physiotherapy were easily described using imagine of relationships between information from content of the notes, photographs, drawings and transcripts of the interviews. Interviews transcripts were analyzed thematically by three researchers using the immersion/crystallization approach, which emphasizes gaining an in-depth knowledge of the data to identify key themes. Data collection and analysis were conducted sequentially. The analysis team drafted a coding scheme based on the conceptual model, discussion of findings, and initial impressions from the data. Four pilot tests for validation of the *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*.

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

Convenience sampling was used to analyze the perspective of physiotherapists and patients on EHRs for physiotherapy.

The questionnaire designed to study physiotherapists' perspectives on electronic health records 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 of 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 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 questionnaire were distributed. The questionnaire was also available online from December 2014 to September 2015. For some patients 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.

3 Results and Discussion

A wealth of information was extracted from physiotherapists that participated at 6 workshops (180 physiotherapists in total), more 180 physiotherapists that responded at our developed questionnaire that was online administered, and from interviews with 20 patients for testing the questionnaire developed for assessment of patients perspectives on ICT for physiotherapy, and 366 patients participants at survey.

As can be shown in Fig. 1 the physiotherapists' main domain of intervention is related with movement disorders.

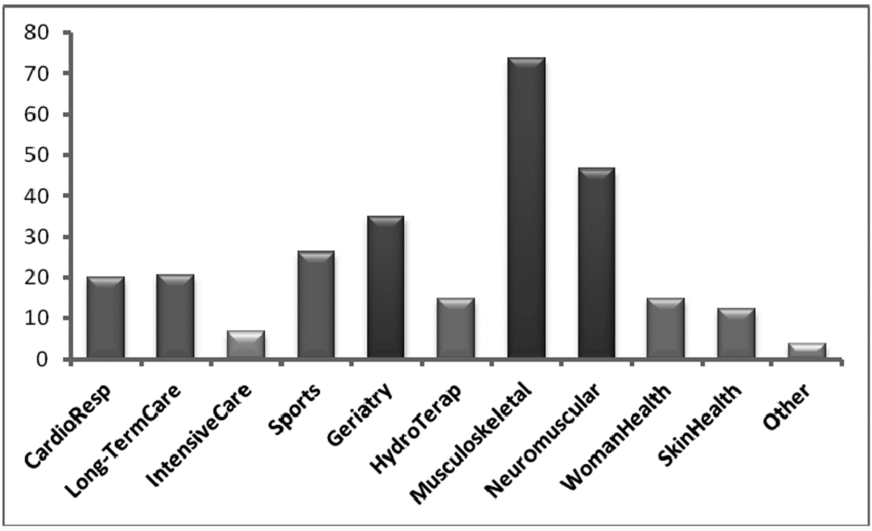

Fig. 1. Domains of interventions and percentage of physiotherapists who participated at survey, in each domain.

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, to process or to share with their patients or 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.

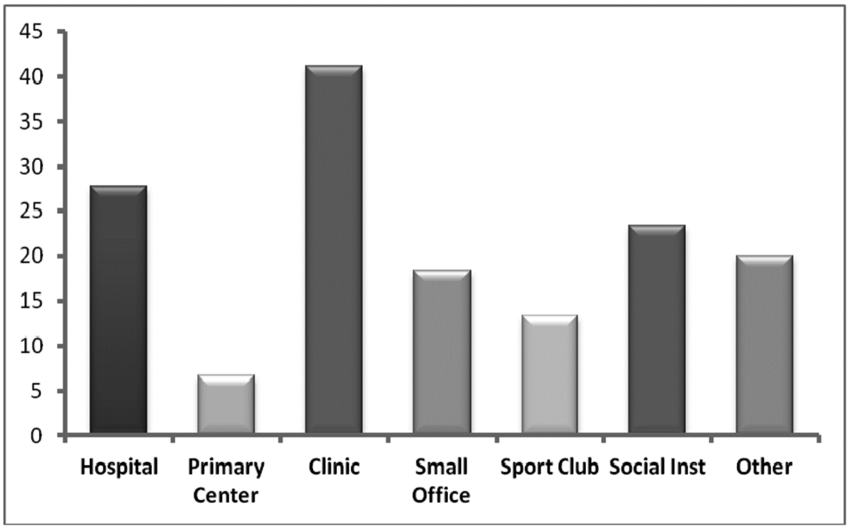

Fig. 2. Workplace and percentage of physiotherapists who participated at survey, in each workplace.

Based on our research work we suggest that for better requirements elicitations discussions in groups of physiotherapists with high level of similarity in practice shall be organized. Low time availability for organization of meetings for discussion of the needs, requirements and barriers of implementation of EHRs for physiotherapy, geographical distance and lack of financial support were the main reasons for low physiotherapists' participation in requirements elicitation. Moreover, difficulty of physiotherapists and their patients to comprehensively describe their needs and the process of interventions as well as properly understanding of physiotherapy process 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 [10–12] 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: heavy documentation, wikis, videoconferencing, etc.; collaboration, knowledge transfer between stakeholders; effective informal communications between physiotherapists with similarity in practice and ITC developers; identification and addition of more requirements in the following discussion; 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 [13]. 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 analyze 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 expectation. 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 selection of theory and practice informed requirements, the mapping of present infrastructure into its' theoretical determinant' should be carried out in order to identify potential levers for change. This assessment 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 indicate as more important for future development the personal computer, internet, and technologies that allow in home physiotherapy through online training with physiotherapists (see Fig. 3, scale 4–5). These data should be analyzed 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 (Figs. 4 and 5).

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: 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 [14–16]; 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 [17]; health literacy – at least in Portugal, various educational and health preventive programs were organized in order to raise awareness on potential of using devices for vital signs monitoring for prevention and disease management of

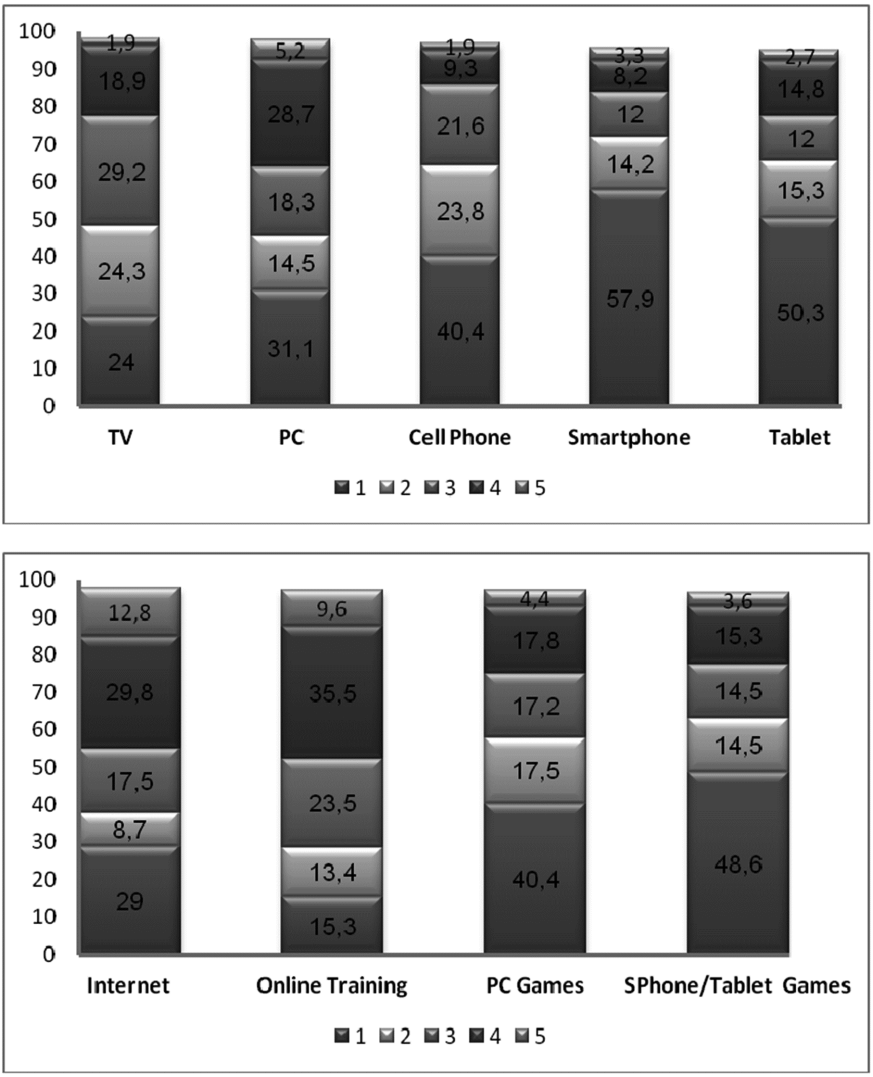

Fig. 3. Perceived importance of technologies in future development of physiotherapy. Assessment was made by using Likert scale (1 to 5; 1-no importance; 5-very important). Percentage were calculated for all sample (the difference between sum of respondents and 100% are represented by missing data, as respondents were able to choose the items for each they wanted to give an input).

cardiovascular disorders. Therefore, for increased adoption of devices for physical activity monitoring, and for effective design and implementation of the physiotherapy intervention based on developed ICT, the key should be 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.

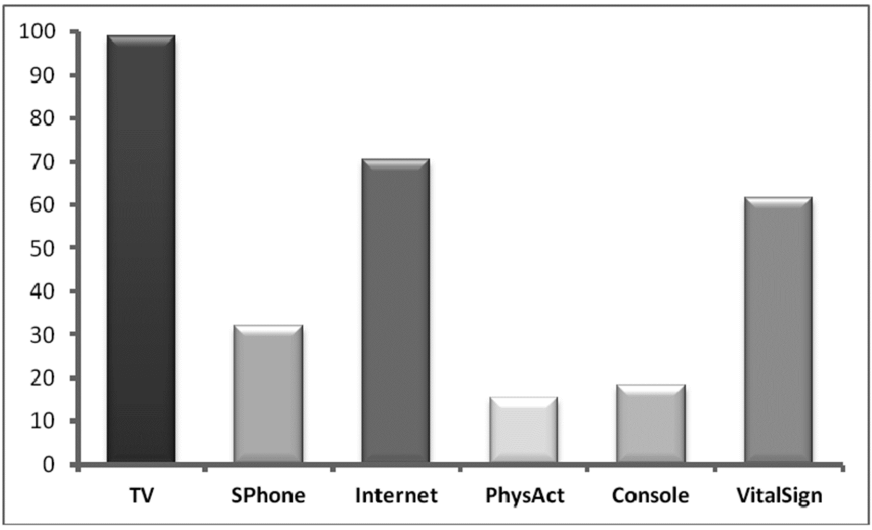

Fig. 4. Percentage of patients that have or had information and communication technologies.

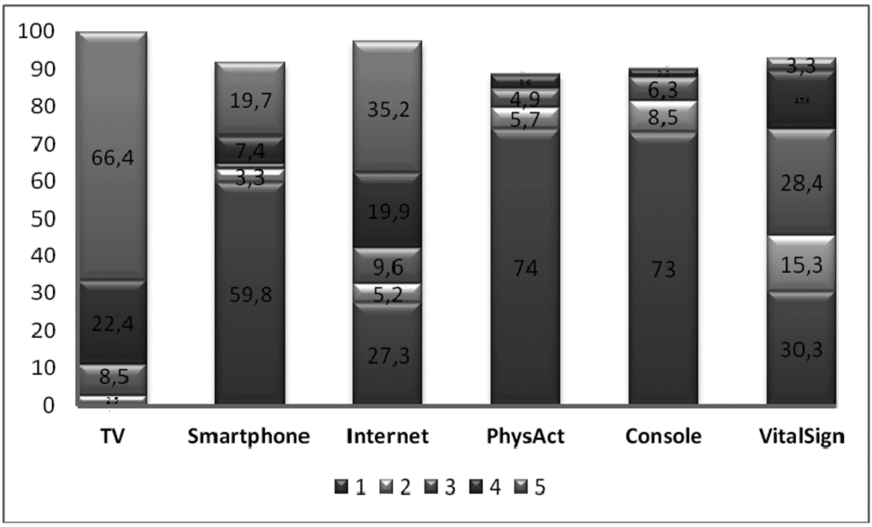

Fig. 5. Percentage of patients that reported use of technologies and perceived frequency of use. Assessment was made by using Likert scale (1 to 5; 1-no use; 5-always use). Percentage were calculated for all sample (the difference between sum of respondents and 100% are represented by missing data, as respondents were able to choose the items for each they wanted to give an input).

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. 6). However, they reported that

they would like to have access to technologies for clinical process and electronical devices that should improve assessment and monitoring of physiotherapy intervention (see Fig. 7).

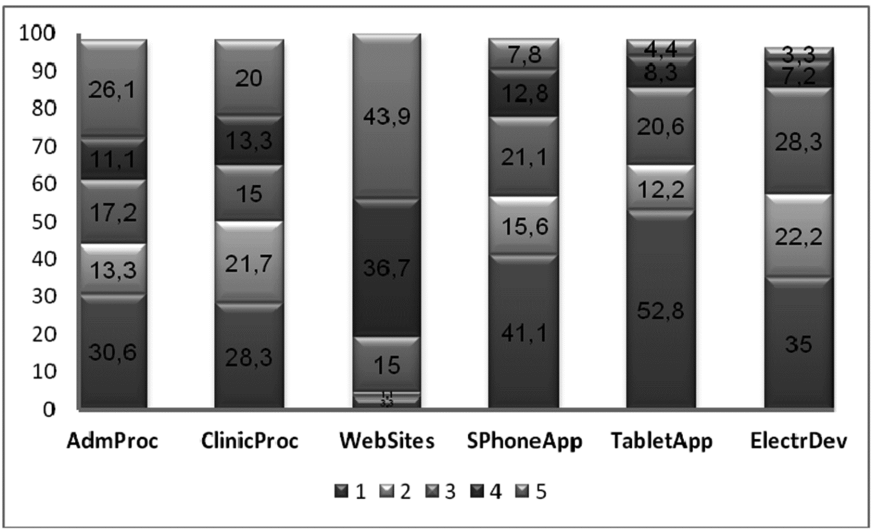

Fig. 6. Percentage of physiotherapists that reported use of technologies. Assessment was made by using Likert scale (1 to 5; 1-no use; 5-always use). Percentage were calculated for all sample (the difference between sum of respondents and 100% are represented by missing data, as respondents were able to choose the items for each they wanted to give an input).

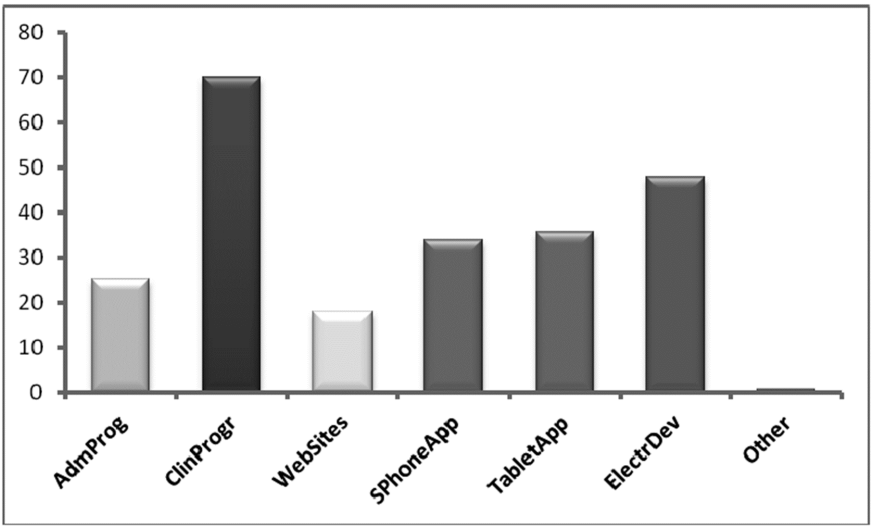

Fig. 7. Percentage of physiotherapists that indicate what they would like to use in physiotherapy practice.

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.) [18]. In the last years, electronic devices were developed to be integrated 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 [19]. 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 [20]. By using this technology, algorithm based on acquired movements that replicate common situation in everyday living, can be used for designing serious games.

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 coexist and interact in real time) might 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 is also presently analyzed 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 indicate various barriers of the adoption of ICT in physiotherapy,

mainly those related to: lack of financial incentive for ICT implementation; lack of information system developers knowledge on physiotherapy processes and workflow; 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 [21]. 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 [22]. 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 [23]. Majority of the physiotherapists that participated in our survey reported low and very low level of knowledge on ICT (see Fig. 8). One solution for this would be organization of online database similar to HELM Open data base 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.

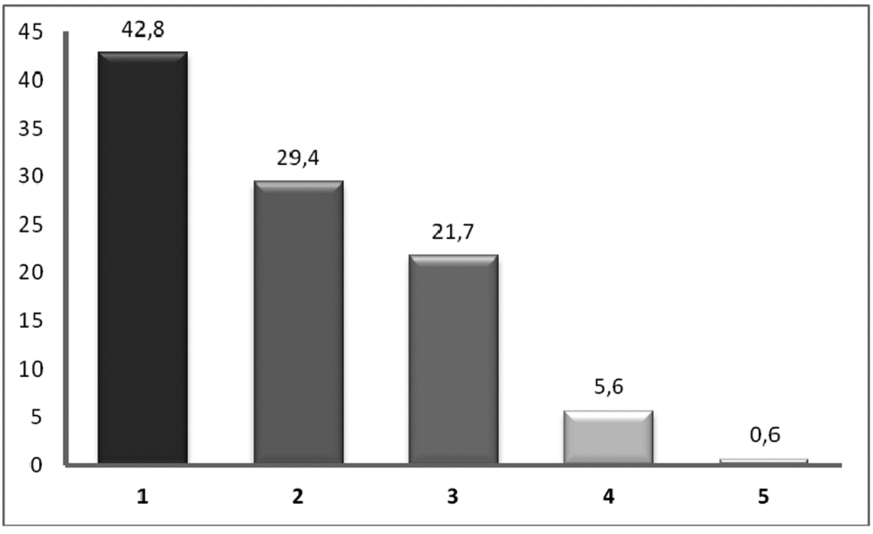

Fig. 8. Percentage of physiotherapists that reported level of information and communication tecnologies knowledge. Assessment was made by using Likert scale (1 to 5; 1-very low level; 5-very good level).

Also, activities that incentive the physiotherapists to work with software for storyboarding (i.e. StoryBoardThat, Google SketchUp), software for ease creation of mobile apps (i.e. AppInventor), software for easy serious game design (i.e. Scratch, GameMaker, GameGuru, ItyStudio, Unreal Engine, Unity – Game Engine) might contribute for better design of ICT tools for physiotherapy. 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*" [24]. In their very informative study Kaye et al. [25] 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"*.

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 ICT progress might 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 needed (between public authorities, ICT providers, associations of physiotherapists and other health professionals, patient organizations, reimbursement scheme providers, insurer, medical devices and information technology regulatory organizations) for integration of ICT in physiotherapy practice.

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