PERSONAL TECHNOLOGY USE AMONGST STROKE PATIENTS: UNDERSTANDING THE BEST PLATFORMS FOR THE DESIGN OF HEALTH INTERVENTIONS IN TREATMENT AND REHABILITATION

Ciccone, Nicholas William (1);
Dornonville de la Cour, Frederik L (2);
Thorpe, Julia Rosemary (3);
Forchhammer, Birgitte Hysse (4);
Maier, Anja (1)

1: DTU – Technical University of Denmark;
2: University of Southern Denmark;
3: Novo Nordisk A/S;
4: The Danish Stroke Association

ABSTRACT

Europe's healthcare systems are under strain with an ageing population contributing to increased risk of strokes. Rapid technology adaption is needed to prevent, rehabilitate and manage symptoms. This paper identifies what technology platforms are most familiar and accessible to stroke patients to guide designers and engineers to develop future interventions. A survey was distributed to 100 inpatients at a stroke unit, identifying patients' accessibility and usage of personal technologies. Results showed that desktop/laptops and smartphones were most used as opposed to tablets and smartwatches. Different technologies were used for different tasks with a notable lack of devices used for personal health. The underlying reasons for this are discussed with recommendations made on what personal technology platforms should be implemented by designers and engineers in technology-based health interventions.

Keywords: Technology, New product development, User centred design, Stroke, Intervention

Contact:
Ciccone, Nicholas William
Danish Technical University (DTU)
Management Engineering
Denmark
nicic@dtu.dk

Cite this article: Ciccone, N. W., Dornonville de la Cour, F. L., Thorpe, J. R., Forchhammer, B. H., Maier, A. (2021) 'Personal Technology Use Amongst Stroke Patients: Understanding the Best Platforms for the Design of Health Interventions in Treatment and Rehabilitation', in *Proceedings of the International Conference on Engineering Design (ICED21),* Gothenburg, Sweden, 16-20 August 2021. DOI:10.1017/pds.2021.503

1 INTRODUCTION

Currently, Europe has an ageing population, a trend that is set to continue with median ages predicted to rise through to 2100 (United Nations, 2017). Age is one of the biggest risk factors of developing a stroke; therefore, projections indicate that between 2015 and 2035, there will be an overall increase of 34% in total number of stroke events in Europe (Stevens *et al*., 2017). In 2015, direct healthcare costs of stroke alone added up to €20 billion in Europe, while costs indirectly due to informal care by family and friends and lost productivity caused by morbidity or death are estimated to be another €25 billion (Matchar, 2015). Moreover, two in five stroke survivors are discharged from hospital requiring help with daily living, with only three in five EU countries being able to offer outpatient therapies (Royal College of Physicians, 2016). Rapid technological adaptation is required to maintain care (Ting, Carin, Dzau, & Wong, 2020).

Current recommendations have been set out to curb the impact of stroke in Europe (Norrving, et al., 2018): One of the key ways of doing this is through fast and concerted delivery of technology-based stroke prevention / rehabilitation interventions. To implement these interventions successfully there have been moves away from traditional healthcare models to more Predictive, Preventive, Personalised and Participatory (P4) medicine (e.g. Hood, 2013; Hood *et al*, 2017) with ample opportunities for design (Patou *et al*., 2020). This is essential to achieve the cost-efficiency, clinical efficacy, equity of access to care and the economic sustainability needed in today's healthcare landscape (Patou & Maier, 2017). Designers and engineers have been turning to digitisation and harnessing technology to gain an increasingly better understanding of human interaction, evidence-based interventions and the underlying mechanisms of chronic diseases. This deeper knowledge will reduce the burden on healthcare systems (Sagner, et al., 2017). Technology use in healthcare is setting new horizons of care efficiency and quality to help people live healthier lives through a complex network of interrelated tools and systems; and some have even called it, the start of a golden age of wearables (Wilson, 2017). The role of personal technology more widely and its capacity to facilitate better prevention and rehabilitation care is becoming more apparent (Free, et al., 2013), with research into the feasibility of self-administered prevention measures and treatments of stroke symptoms being tested to enable patients to be more independent (Macoir, Lavoie, Routhier, & Bier, 2019).

This paper identifies the current gap in knowledge of what technology a sample of Danish stroke patients have access to, if they use information and communication technologies and if so, for what purpose. The aim of this study is to provide designers and engineers with information on the platforms of technology which patients have the greatest familiarity with and therefore might be the most viable when designing interventions. This supplements the development of devices and applications for detecting stroke risk factors, self-monitoring, and adherence to medication routines. Results are envisaged to aid implementation of interventions, with the hope of improving the current gaps in long-term support and follow-up to evaluate stroke survivors' needs and quality of life.

2 LITERATURE BACKGROUND

2.1 Personal technology and the elderly

There is a misperception that the elderly are less receptive in adopting new technologies in comparison to the younger generations (O'Hanlon, Bond, Knapp, & Carragher, 2010). Interventions are relying more on technology to monitor health-related behaviours and to reduce mortality. This is key as current healthcare trends are pointing towards decentralisation of care as one of the main coping mechanisms in system redesign to a more effective healthcare delivery system (Patou & Maier, 2017). One of the ways this would be made possible is by the use of mobile or some other personal health technology at home. Older adults may be slower to adopt than younger adults (Czaja, et al., 2006) and technology experience / competence declines with age (Goodman-Deane, Bradley, & Clarkson, 2020). However, older members in society still use technology for everyday tasks. Across the whole of the EU-28, just over one quarter (26 %) of elderly citizens use internet banking, 27 % make online purchases, 31% use the internet for reading news and 16% for social networking (Eurostat, 2017). As well as aiding in general tasks there is a particular interests in those technologies that appear to add value e.g. maintaining quality of life by improving or sustaining their physical and mental abilities (Heinz, *et al*., 2013). There is remaining uncertainty around the depth and breadth of technology use by the older population.

2.2 Barriers of use

Understanding technology patterns of use and the barriers of adoption in general in older adults can provide insights into appropriate ways of introducing technology to older citizens. This may also give insight of why some technologies are shown preference over others. This is important for the implementation of new healthcare interventions. Previous studies have reported the acceptance of health-related ICT among elderly people (Vassli & Farshchian, 2018) and the barriers associated with its use (Whitelaw *et al*., 2020; Palacholla, 2019). These centred on the daily needs and challenges associated with technology usage, how technology is helpful and what would make technology easier to use. Evidence indicates that attitudes and abilities are among the most powerful predictors of technology use. Cognitive deficits and low self-efficacy associated with older age significantly reduces participants' ability to use technology (Dou *et al*., 2017). This is of particular significance when applied to stroke patients, which may be experiencing cognitive, perceptual, or motor deficits because of their condition (Alvseike & Brønnick, 2012). More generally, stroke rehabilitation, diagnosis and management is currently fragmented with treatment being given by various medical specialists at regional and local level, this is often due to technology access and availability. Low levels of communication among specialists from hospital to municipality and limited information to the general practitioner and patient risk creates discontinuous care and inefficiencies (Stroke Alliance for Europe, 2019). The limited capabilities to monitor the longitudinal effectiveness and cost of interventions from diagnosis to rehabilitation create uncertainty when validating technology healthcare delivery changes, which is especially important when designing for value-effectiveness (Auerbach, Kripalani, & Vasilevskis, 2016).

In sum, the current literature suggests that older adults are generally open to using technology which brings increased portability and communication, but age-related (e.g., cognitive decline) as well as technology-related (e.g., interface usability) barriers are off-putting to some users (Heinz, *et al*., 2013). Combining these age related barriers with systemic issues (e.g limited technology access, and fragmented care) the obstacles for the implementation new technology creates further challenges when designing interventions.

2.3 Personal technology platforms

Thanks to the development of new technology platforms such as tablets and smartwatches, and an appetite from users in adopting the subsequent devices there are increasing opportunities to improve quality of elderly care. A literature review of what technologies are currently being used for in clinical studies dealing with elderly adults found desktop computer, notebook, tablet, smartphone & smartwatch to be the most common platforms (Osvath, Kovacs, Boda-Jorg, Tenyi, & Fekete, 2018). As the population ages a similar trend is being observed in the computer and internet users. Older adults are the fastest growing group of computer users in both personal and workplace environments (Wagner, Hassanein, & Head, 2010). They represent a minority compared to the younger population (Hart, Chaparro, & Halcomb, 2008) but are a keen in participating in technological developments (Juznic, Blazic, Mercun, & Plestenjak, 2006).

The desktop computer has been a mainstay in many homes for the last two decades and represents a familiar platform. However, the use and design of handheld computers for older adults has been rapidly evolving (Zhou, Rau & Salvendy, 2012), with the pattern of user behaviour evolving with age. The most common tasks involve communication and social support (Thayer & Ray, 2006) and as a tool to overcome geographic boundaries or limitations to mobility (Alexy, 2000). Mobile devices (smartphones and tablets) have been universally adopted in people's everyday lives (Lee, 2014). This has led to the creation of millions of services and applications to facilitate and simplify daily tasks (Song, Kim, Jones, Baker & Chin, 2014). The smartphone platform can help deliver preventive medicine, healthy lifestyle messaging and interventions (Pratt, Sarmiento & Montes, 2012). There have already been many initiatives that utilise smartphones: mEducation, mHealth, mIdentity, Smart Cites and Connected Europe. These investigate the potential benefit of delivering the growth, sustainability and innovation objectives in the EU 2020 strategy (GSMA, 2019).

With recent advancements in the mobility of technology, personal wearable health technology have been utilised both as a preventative strategy to the development of disease or as part of the rehabilitation process (Thorpe, Forchhammer & Maier, 2019). This is particular important regarding the Predictive, Preventive, Personalised and Participatory (P4) healthcare model where all stakeholders are encouraged to utilise technology to expand the reach and impact of initiatives and interventions

(Sagner *et al*., 2017). Better data collection will help accurately predict an individual's health vs. disease risk allowing for individually tailored health messaging to create more relevant motivational goals to strive for.

Tablets offer the same functionality as a desktop at a smaller, more flexible size and weight (Vaportzis, Giatsi Clausen & Gow, 2017). While also having a larger screen, icon and text size than a mobile phone which is better suited to those with motor or visual impairment (Zhou, Rau & Salvendy, 2014). A recent and fast-growing market of wearable devices is smart watches. These super portable computers have miniaturized form factors and an array of biosensors (physiological data derived directly from skin contact (Scher, 2015). This combination means that it can be worn continuously, while collecting rich data without interrupting the user's daily activity. This provides a high level of ecological validity, useful in a variety of healthcare applications. These watches often serve as an extension to smartphones, which are already owned by a large population of older adults. Many other studies are investigating uses for smartwatches in healthcare (Lutze & Waldhör, 2015).

Many factors should be considered when choosing a technology platform in order for it to best fit the intended purpose of an intervention or rehabilitation programme (Bain, Flynn, & Stroud, 2018). These can originate around data, its quality and the type of sensors a device uses. This is important in order to capture robust enough information to learn about and intervene in the targeted domain. This sets a president for how data and algorithms translate from research to applied medicine. Concerning more practical considerations, the length of availability to buy and repair a device is important when considering data collection which may result in longitudinal studies. This is especially true for rapidly developing platforms where older models quickly become obsolete; sustainability is becoming an important factor in device selection.

2.4 Personal health technology and stroke rehabilitation

While conventional post – stroke rehabilitation such as physiotherapy and occupational therapy focuses on the restoration of motor function, it has been noted that there are limitations in the extent to which it improves quality of life (Broeren, et al., 2008). This kind of rehabilitation requires considerable resources in terms of time and labour. Effectiveness is further exacerbated by the requirement of good patient adherence and the geographical boundaries associated with where the resources are to conduct the therapy, ultimately resulting in inconsistent levels of care (Hubert, *et al*., 2019). Clinicians' current preference is for face-to-face interactions but use telerehabilitation when face-to-face is not feasible (Caughlin *et al*., 2019). However there has been a recent urgent need to shift to socially distant therapy due the recent coronavirus outbreak. The effectiveness of tele-stroke programs to connect centrally located neurological experts to rural healthcare facilities, to improve stroke care for stroke patients by using interactive telecommunication technology has already been documented with increased value and effectiveness (Kulcsar, Gilchrist & George, 2014). The ergonomic nature of the device needs to match the intended users (Caughlin, *et al*., 2019). Stroke patients often experience motor impairment, communication difficulties (aphasia), visual deficits and physical/mental fatigue in addition to the previously mentioned barriers (Vatavu, 2017). These symptoms can either be exacerbated by or alleviated by the correct technology modality of rehabilitation delivery. Understanding barriers for use, and the state of current technology platforms allow for more informed solution-creation by engineers and designers.

To help underpin this application of technology in stroke rehabilitation and care, a snapshot needs to be taken of the current familiarity and use of stroke patients regarding their personal technology platforms. This will inform future designs to facilitate the pre-existing knowledge of patients.

3 MATERIALS AND METHODS

A survey on technology use was designed for 100 in-patients who had suffered a stroke, based on an existing survey for individuals with reduced cognitive capabilities (dementia).

3.1 Questionnaire design

The questionnaire was designed to examine patients' use of technological devices before hospitalisation. In the planning phase a group of in-patients, neuropsychologists and language therapists were involved in constructing and designing the questionnaire. A feasibility test was performed and the questionnaire was adjusted accordingly. Patients were over a period of three months consecutively enrolled in the study. Completion of the questionnaire takes approximately 5-20 minutes. First, demographic information was recorded, including sex, educational level and living arrangement, and then the questionnaire was administered. The questionnaire has three sections, of which the first is mandatory and the two following are adapted based on responses to items of the first section: accessibility of technological devices at home, use of accessible technological devices, and reasons for not using any of the technological devices.

The first section assesses whether or not the respondent has access to one or more of the following devices at home: Computer, smartphone, tablet, and smartwatch. If the respondent has access to one or more devices, section two is administered for each accessible device. If the respondent does not have access to any of the four devices, or never uses any of their accessible devices, section three is administered.

In section two, the usual frequency of use of the specific device (before hospitalization) is scored on a five-point ordinal scale from “Daily”, “One or more times a week”, “Rarely”, “Never, I do not use it anymore” to “Never, I have never used it”. Purposes of use are scored on five binary variables based on what is mentioned in a free response: “Leisure and entertainment”, “Communication” (including social media), “Safety”, “Practical tasks”, and “Others”. Finally, need for assistance was scored on a three-point ordinal scale from “Yes, I am dependent on others help”, “Sometimes/for some matters”, to “No, I am using it independently”. These items were completed for each accessible device. If the respondent never uses a specific device, rest of the items were skipped.

Section three assesses reasons for not using any of the technological devices. Reasons are probed by an open-ended question and scored on five binary variables depending on what is mentioned in the free response: “Lack of knowledge”, “Lack of skills or support”, “Lack of interest/motivation”, “Too expensive”, and “Others”.

3.2 Survey procedure and inclusion criteria

A neuropsychologist, working as research assistant at Rigshospitalet Glostrup, visited the stroke unit once or twice a week during a period of three months. During these visits, the neuropsychologist approached available patients, informed about the survey and invited them to participate in the study. Participants provided informed consent and completed the questionnaire at bedside with the neuropsychologist reading the questions aloud, correcting any misconceptions, and recording responses on a laptop. If relevant, visual aids were provided to support communication; see example in Fig. 1.

Figure 1. Example of survey questions on technology use among stroke patients.

When present, close relatives were invited to contribute with objective data, e.g. responses to questions about age, education, and accessibility and frequency of use of technological devices. Data about attitudes, however, e.g. subjective reasons for not using technology, were asked to be provided independently by the participant and was recorded as missing data if the participant was not able to provide these data validly.

Inclusion criteria were 1) active hospitalisation at the stroke unit and 2) Danish-speaking. Participants were excluded if they 1) had already participated in the survey during earlier hospitalization (e.g. in case of a recurrent stroke), 2) had a lack of consciousness or severe cognitive or communicative impairments interfering with the validity of responses to the questionnaire, or 3) were in significant distress. The neuropsychologist collecting data evaluated if participants were able to provide valid responses and conferred any uncertain cases with a senior neuropsychologist.

4 RESULTS

One hundred participants completed the survey. Fifty-four participants were male. Ages ranged from 44 to 94 years with a mean age of 69 years. Sixty-nine percent of the sample was at least 65 years old. One participant's response was excluded because of errors in responding.

Desktop computer/laptop was the most accessible of the technological devices with 84% of participants having access to this device (Fig. 2). Of these, however, 29 participants had not used their computer within the latest month before hospitalisation, whereby 55% of the total sample were using a computer. This proportion is similar to the proportion using a smartphone. While just 52% of the sample had access to a smartphone, 49% of the total sample were using it within the latest month before hospitalization. Tablets (40%) and smartwatches (8%) were less likely to be accessible and were used by lesser proportions of participants (29% and 6%, respectively). Thirteen percent of the sample did not have access to any of the four technological devices. Furthermore, 31% was not using any of the technological devices in the latest month before hospitalisation.

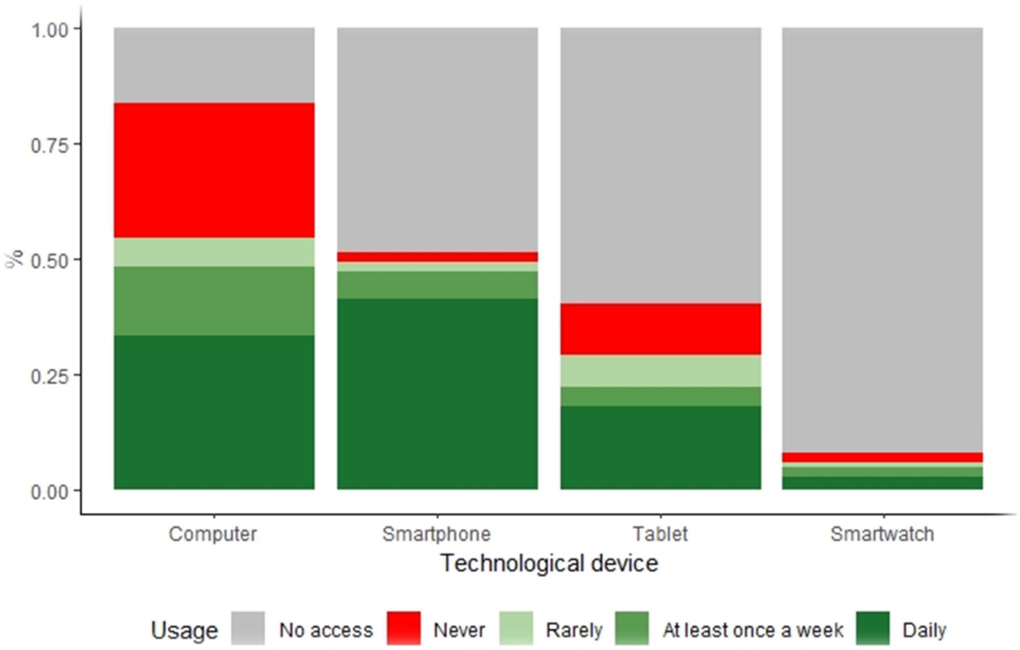

Figure 2. Technology access and frequency of use (n=100)

Anecdotally, in the questionnaire, the most frequently mentioned purpose with using a computer was for practical tasks (Fig. 3), e.g. reading e-mail and "eboks" (digital official mails), financial affairs (accessing bank account, paying bills), work, e-shopping, and seeking information. For a smartphone, the most common type of tasks mentioned was communication and social activities. Patients mentioned using the smartphone for reading e-mails, texting and making phone calls, and using social media platforms. The most common purpose for using a tablet was leisure and entertainment, e.g. reading news, streaming, and listening to music or reading e-books. None of the participants mentioned using any of the technological devices for safety purposes, such as being able to call for help in an emergency.

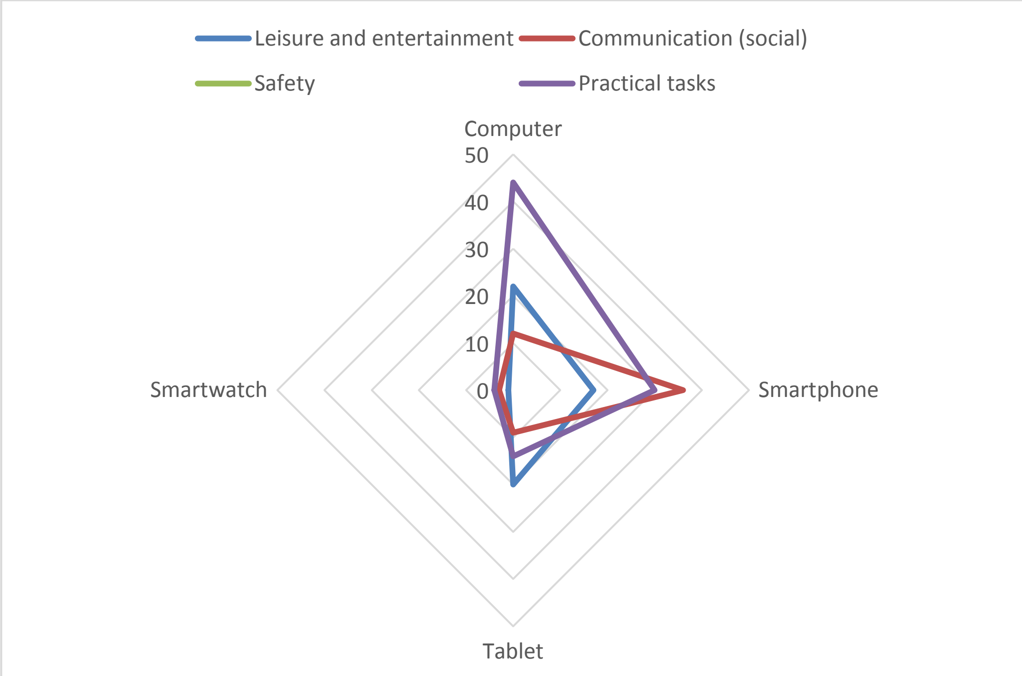

Figure 3. Technology use purpose amongst stroke patients (n=100)

5 DISCUSSION AND LIMITATIONS

The results indicate that the majority of stroke patients have access and use at least one technological platform. Desktop computers were the most accessible but smartphones were the most used if the participant had access to the platform. This would suggest these as the most adopted and appropriate technologies for the design of patient rehabilitation tele and e-health interventions which are situated outside of healthcare hubs. Tablets and smartwatches, which are the newer platforms, had lower levels of access. This may be due to older adults being slower to adopt newer technologies than younger adults (Czaja *et al*., 2006), however they still provide a viable platform to passively monitor a patient's behaviour and symptoms, until older adults become more accustomed to them. So these devices should therefore not be discounted by those designing current healthcare interventions.

None of the patients reported use of technology for "health & safety" purposes in the latest month before injury. There are currently several interventions in place that monitor progress of stroke rehabilitation (Patel, et al., 2010), this should be an area of expansion. Both in preventative strategies involving the older generation in intervention through education and public health messages that focus on the benefits of using their personal technology for health information reducing the risk factors associated with stroke. Alternatively, personal technology can take an active role in stroke recovery via prompts for physiotherapy (Micallef, Baillie & Uzor, 2016), confidence boosters with improved communication to family and caregivers and also in routine assessment of cognitive ability (Olivirs *et al*., 2014). The results of this study suggest, however, that clinicians, designers, and engineers should be careful to assume that all stroke patients are acquainted with and interested in the use of technological devices. Thus, educating and prompting the use of such technology would also address some of the barriers associated with nervousness or lack of ability or motivation in adopting new technology (Wagner, Hassanein & Head, 2010).

While we aimed at reaching as many eligible patients as possible being admitted to the stroke unit during the three months of data acquisition, we did not succeed at reaching all patients. For instance, some patients were busy with treatment activities when the neuropsychologist visited the stroke unit, e.g. attending physiotherapy, occupational or speech therapy, ward rounds, scanning, etc., combined with a short stay in hospital. Unfortunately, we have no data on how many patients from the stroke unit that were excluded or did not participate in the study for other reasons during the period of data acquisition.

Which brings us to a limitation of this study concerning generalisability. First, all participants were recruited from a single stroke unit, receiving citizens from a fixed range of municipalities in Denmark.

This demographic limitations has a cultural factor. It has been previously argued that the use of technology only results in better health if the related cultural challenges are acknowledged and the new needs of patients are met (Meskó *et al*., 2017). We know technological transitions have been happening rapidly, in particular social media and penetration of smartphones (Steinhubl, Muse & Topol, 2013). However the rate of the needed cultural revolution is not always on par. This impacts the aged of society the greatest, who are often being left behind in terms of education and integration. This disparity is not equal with some countries older population become increasingly assertive about their rights to care (Coleman *et al*., 2003). This is particular true in Denmark and may reflect the high level of technology use seen in this particular patient group. Older users in Nordic countries have been involved in the early stages of service design as more experienced sources of innovation. This empowers the patient and does well to improve technology culture (Essén & Östlund, 2011). Such a culture of inclusivity may be the driving factor of the reduction of time between the release of a technology and the uptake of it by elderly users, which varies from country to country.
Secondary, the sub-population may differ from the general population in Denmark with regard to income, education, social status, etc. Second, we did not record pre-existing illnesses or previous strokes, which may affect the use of technological devices. Third, lower degree of disabilities following stroke tends to be associated with purer premorbid function. As we excluded patients with severe functional disabilities, e.g. severe aphasia or amnesia, the results may have a tendency to overestimate the access and use of technological devices in the elderly. The results do however provide a good understanding of what technology able participants tended to use and what for. A larger scale survey should be conducted in multiple countries, e.g. in Europe which will enable more informed intervention creation.

6 CONCLUSION

This exploratory survey with responses from 100 elderly stroke patients in Denmark serves as a preliminary evaluation of the technology most accessed and used by stroke patients of a hospital within the Capital Region of Denmark (Region Hovedstaden). There is a need for the utilisation of technology in rehabilitation practices that the current generation of older adults in Europe have familiarity with to address the immediate impact higher stroke numbers are having on healthcare systems. As the younger population ages there will be more technology literacy, which will facilitate better uptake of technology-based interventions.
Results highlight Danish citizens in the Capital Region of Denmark as a personal technology leaders with the majority of the older patients having access to at least one technology and using it regularly (84% desktop computer, 55% smartphone, 40% Tablet and 8% smartwatches). This positions Denmark well as a country to test new telemedicine stroke-rehabilitation interventions based on personal technologies platforms aimed at the aged. The outlook for current European systems looks challenging with the aging population, especially with COVID-19 straining care. Having said this, there is evidence here that the older generation has enough technology familiarity to overcome barriers previously thought to be hampering for reduction in healthcare strain through personal technology allowing for more informed solution-creation by engineers and designers.

ACKNOWLEDGEMENTS

This work has received funding from the Horizon 2020 research and innovation programme of the European Union under grant agreement no. 871767 of the project ReHyb: Rehabilitation based on hybrid neuroprosthesis.

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