ARCADA

The use of wearables in healthcare – challenges and opportunities

Jonas Tana[i], Maria Forss[i], Thomas Hellstén[i]

Abstract

Shortage of skilled healthcare personnel with the required Information- and communication technology competence have been common because of the fast pace of technological innovations. To ensure a sustainable and secure development in health and welfare, there is a need for future professionals to have an understanding of the new digital data on individuals, clients and patients that are emerging in healthcare with the new wearable devices. The aim of this article is to discuss the opportunities and challenges for professionals meeting the digital individual and the data produced on them by new wearable technologies. The road from patient to digital patient is today a challenge for both individuals and professionals, as well as for the society.

Keywords: wearables, monitoring, eHealth, healthcare, digital health

1   INTRODUCTION

Information- and communication technology (ICT) plays a significant role in society today. Digitalization is changing all areas of human behaviour, from social settings to basic needs, like health related matters. The impact of new technology on improving health and well-being of individuals and populations is unprecedented, which even makes us talk about a *digital revolution* in healthcare (Birkler & Dahl 2014). The digital revolution offers an opportunity to transform healthcare and empower citizens in taking charge of their own health (Kostkova 2015). For the larger population, adoption of new technology has transformed from a slower pace to a faster adoption, and nowadays health related applications and devices are being used by many individuals (Birkler & Dahl 2014). Monitoring of the human body has advanced over the years, from bedside

---

[i] Arcada, Department of health and welfare, [jonas.tana@arcada.fi]
[i] Arcada, Department of health and welfare, [maria.forss@arcada.fi]
[i] Arcada, Department of health and welfare, [thomas.hellsten@arcada.fi]

monitors in the hospital, to wearable devices that can monitor individual's physiological functions 24 hours a day (Omoogun et al. 2017). The digital revolution also refers to the possibility to collect, transmit, and analyse large quantities of digital data related to health and medical conditions with the help of monitoring devices (Klonoff 2013). This means that more and more data is generated and stored digitally about individuals, clients and patients and their behaviour related to health (Birkler & Dahl 2014). Life is now also digital, in most avenues of everyday life, and people cannot easily escape becoming a subject of digitization and therefore reconfigured by computer code (Lupton 2016). The vast amount of information created by new measuring devices creates big data sets that can be used to predict, prevent and treat public and individual health (Birkler & Dahl 2014).

This rise of digital healthcare brings about a demand for specialized skills. The changes that technology brings will call for a different type of employee. These shifts also require a new or an enhanced set of knowledge, skills and attitudes with renewed focus on the individual (Salmond, S. & Echevarria M. 2017). Shortage of skilled healthcare personnel with the required ICT competence have been common because of the fast pace of technological innovations. In the healthcare sector, this has partly been the reason for the slow uptake of ICT solutions (Salmond, S. & Echevarria M. 2017). The need for digitally skilled healthcare professionals is acknowledged at European Union level, and several initiatives have considered this need. The European Commission's eHealth Action Plan 2012-2020 provides a roadmap to empower patients and health workers skills and digital literacy (Xianqing 2016). In order to make full use of the potential that digitalization brings about we need knowledge and understanding of the new aspects brought forward (Kostkova 2015). One essential aspect is the digital data produced by individuals, clients and patients that can be seen a prerequisite for a more efficient and precise healthcare (Tjora 2014; Kostkova 2015). The use of digital data also lies as a basis for a fully sustainable, data-driven, health care system that will offer truly personalised healthcare (Piwek 2016).

To ensure a sustainable and secure development in health and welfare, there is a need for future professionals to have an understanding of the new digital data on individuals, clients and patients that are emerging in healthcare with the new wearable devices. *The aim of this article is to discuss the opportunities and challenges for professionals meeting the digital individual and the data produced by wearable consumer oriented monitoring devices.* By understanding the opportunities and challenges that this rather new data brings, we can ensure the quality of evidence-based healthcare. This is especially relevant in education of future professionals, as it has been predicted that the development of healthcare-wearable technology is creating great opportunities and posing a remarkable future for healthcare services (Wu et al. 2016).

2   THE DIGITAL INDIVIDUAL

In health and welfare, digital data about an individual's contact (or lack thereof) with health and welfare services were previously the only digital traces left behind. With the rise of new ICT innovations, digital traces of human behavioural patterns have accumulated at a breath-taking pace and today we have a myriad of different ways and data

sources to digitally measure and trace individuals and their behaviour related to health. The phenomenon itself is not new as monitoring, measuring and recording elements of life for self-improvement and self-reflection go back to ancient times (Lupton 2016). Telehealth and telemedicine technology, with computerised devices to facilitate remote monitoring, have been in use since for many decades. However, the recent developments in digital health technologies have led to a renewed and larger interest in wearable devices that measure a myriad of bodily functions and human behaviour (Lupton 2016). These digital applications, whether *insideables* or *wearables*, have become an important element of monitoring and measuring human physiology and behaviour, and are growing rapidly in numbers. This development has led to not only patients who engage in self-management of their condition being monitored, but also individuals in a growing amount. Smartphones now routinely include sensors such as GPS, digital compasses, gyroscopes and accelerometers that can be employed for monitoring movements. Some smartphones also incorporate heart rate, body temperature, humidity, atmospheric pressure and air temperature sensors. (Lupton 2016)

The line between these so-called consumer health wearables and medical devices is beginning to blur, and potentially, consumer health wearables could give individuals direct access to personal analytics that could contribute to their management of health and illness (Piwek et al. 2016). The use of measuring devices is not only limited to adults as children are also targeted for self-tracking by a plethora of software, apps and devices. Even unborn babies have become targeted by these technologies (Lupton 2016). Societal movements such as the quantified self-movement, are being increasingly joined by individuals, with the aim to monitor and measure elements of health (Shull et al. 2014; Lupton 2016). The field of actors in digital health applications is also in flux. There are many actors, outside the traditional health and welfare arena that are now entering the health arena. For instance, large internet companies like Nokia, Apple, Samsung, Google and Amazon have unveiled projects and products within the digital health field aimed at consumers. New stakeholders with their own interests are also entering the health arena, and arguments for persuading citizens to engage in self-monitoring through wireless devices are becoming increasingly common. For instance, insurance companies are showing an increased interest in this phenomenon and are already encouraging and rewarding their participants for using health-improving wearable technology devices (Nagtegaal et al. 2015).

3 OPPORTUNITIES IN DATA-DRIVEN HEALTHCARE

Data-driven healthcare can be seen as a similar concept as evidence-based healthcare. In both, the process of conscientious, explicit and judicious use of current best evidence in making decisions about care for individual clients or patients is crucial. Data-driven healthcare can be seen as the ability to analyse a wide range of big data, from various sources, to determine what is happening right now with regard to the health of individuals or patients (IBM 2013). Big data in healthcare is overwhelming not only because of its volume but also because of the diversity of data types. The data types include the more traditional clinical data from electronic patient records and sensor data, such as from monitoring vital signs in clinical settings (Raghupathi & Raghupathi 2014). Today, more and more information is created outside the traditional clinical context with

the help of wearable measuring devices. These devices could effortlessly provide detailed longitudinal data to monitor individuals' progress without involving more sophisticated, uncomfortable, and expensive measuring equipment (Piwek et al. 2016). These data or these personal details are now typically transmitted to and stored on cloud computing databases. As a consequence, accessibility to these details are no longer limited to physical space, as was the case in the days of paper journals and records, but personal details are potentially available whenever and wherever, as well as to other actors and agencies (Lupton 2016). As the Internet of Things expands further and sensor-embedded objects and environments become ever more distributed, digital objects will have even greater capacity to connect to and communicate with one another independently of human intervention, constantly creating masses of digital data on a greater number of elements of human life (Lupton 2016). These massive amounts of data has the potential to improve insights into health risks, outcomes, performance and to take prescriptive action. All the amount of information collected on individuals, patients or not, generate big data, which can offer an unprecedented potential to generate insights into human behaviour, clinical decision support, disease surveillance, and population health management (Grossglauser & Saner 2014; Lupton 2016; Raghupathi & Raghupathi 2014). Big data analytics can have the potential to transform the way healthcare providers use sophisticated technologies to gain completely new insights and make informed, or evidence based decisions based on these new insights (Raghupati & Raghupati 2014). The data accumulating within all the digital health services as well as internet companies provide means to study human behaviour at scale, and also allows asking completely new questions about the interplay between behavioural patterns and health (Grossglauser & Saner 2014). These insights would not be accessible without this new digital data, and the implications for health and welfare are potentially enormous. Raghupati & Raghupati (2014) predict that in the near future there will be a rapid, widespread implementation and use of big data analytics across the healthcare industry. Data from wearables devices could this way feed into a broader system of predictive medicine, to detect early symptoms of different diseases (Piwek et al. 2016).

4   CHALLENGES

The implementation of data and analytics from wearable devices aimed at consumers' face several challenges that need to be addressed before non-clinical data from consumer wearables can be adopted in healthcare. One of the main concerns in regards to wearables is the importance to establish validity and reliability of the measuring equipment (Evenson et al. 2015). Clinical research on monitoring devices that have similarities to consumer wearables have involved pedometers and smartphone application to aid inactive lifestyles and obesity as well as solutions for home telemonitoring (Piwek et al. 2016). In contrast with these traditional monitoring devices that have been in use in clinical settings, the accuracy of modern wearable activity monitors have been studied insufficiently (Price et al. 2017). Little or no information is available to confirm the validity of these consumer based activity monitors, especially under free-living conditions (Lee et al. 2014). Even if more and more studies on validity of wearables are being done, Piwek et al. (2016) state that the reliability and validity of wearable devices is concerning. Comparisons between various wearable devices show large variations in accuracy between different devices, with error margins of up to 25% (Piwek et al.

2016). Even if recent studies demonstrate good potential, the lack of reliability and confidence needs to be addressed long before a device can be considered for any clinical application or setting (Lee et al. 2014; Price et al. 2017; Piwek et al. 2016). Validation and reliability also poses another threat, in regards to safety. As Piwek et al. (2016) point out; there is a probable liability that device users become over-reliant on the devices and their automated systems. This may provide a false sense of security and even fuel misdiagnosis.

Another main concern that wearable devices pose is issues with user privacy and security. This may refer to the personal data generated by the devices, but also to the negative consequences, like uncomfortability and intrusiveness, of excessive self-monitoring that consumer wearables may cause (Piwek et al. 2016; Redmond et al. 2014). For some people using self-tracking or wearables represent a way of taking control of one's health, for others it may symbolize weakness, unhealthiness or lack of self-discipline (Lupton 2016). Privacy and security issues has in research literature been somewhat neglected in favour of the more technical challenges of validity and reliability of the data that wearable sensors pose (Redmond et al. 2014). Privacy and security issues have been an important part of healthcare where large amounts of personal data are collected, and are thus in no way unique to wearable sensors. However, the earlier policies and practices that relate to privacy may be insufficient at a time when more and more self-generated data relevant to health are being generated (Health Data Exploration Project 2014). A main concern with wearables when it comes to privacy is in respect to ownership of user data. Users of consumer wearable devices today often do not own their data. Instead, the manufacturer handles data collection and storage, while the end users are, quite paradoxically, only provided with a summary of results based on the collected data. There is also a liability that user generated data is sold to third-parties, and some companies are also sharing user information like location based on Global Positioning System, email, age, sex etc. that have been entered when registering for a service (Piwek et al. 2016). Even if data gathered from wearables are typically anonymized, a simple removal of identifying features is not adequate enough to provide sufficient levels of anonymity and therefore identity fraud or abuse may be difficult to prevent (Health Data Exploration Project 2014; Piwek et al. 2016).

Hacking has become a leading cause of breaches in relation to health data (Filkins et al. 2016). Wearable devices are no exception to this, and these devices may be easy to hack because of the various communication technologies aiding in the process of wireless transferring user generated data (Filkins et al. 2016; Piwek et al. 2016). The consequences of hacks may be reduced for wearables compared to invasive digital equipment, but hacking could lead to health data being abused, distorted or lost (Health Data Exploration Project 2014; Piwek et al. 2016). Improving individual awareness of the security risks can effectively minimize the risks for hacking (Filkins et al. 2016).

There is also another challenge that needs to be addressed. All these new ways of digitally measuring human behaviour and activity create and collect data that construct a representation of the individual being measured. This digital individual consist of all data, related to and about the individual, collected, stored, mediated and deleted in relation to health and wellbeing. This digital data does not have a physical manifestation. However, it is important to emphasize that the digital being also refers to the physical individual that the data is collected from, because without the physical individual there

would be no digital data (Birkler & Dahl 2014). From a physical point of view, the digital representation of the individual can exist in many different places at the same time. Data can be shown whenever and wherever, with the right equipment, and therefore locating the digital individual is difficult. Quite paradoxically, the digital individual does not exist at any concrete place (Birkler & Dahl 2014).

5   DISCUSSION

More and more of the body is being digitalized in the form of quantifiable data, and the individual and physiological bodily functions as well as moods are becoming more and measurable. In relation to this process, Deborah Lupton (2016) poses a good and accurate existential question: without data, am I dead? Or will there, in the future be any information about individuals, unborn, born or dead, that is not digital? (Birkler & Dahl 2014).

For digitally skilled individuals, the utilization of information and communication technology is full of opportunities, from navigating in your own data and prescriptions, to consulting professionals. However, the ones standing on the other side of the digital divide face a huge challenge as health and welfare services are being more and more digitalized. The road from patient to digital patient is therefore a challenge for both individuals and professionals, as well as for the society. For professionals to be able to guide citizens in the use of different measuring devices and applications there is a need to understand the different benefits, challenges and consequences present when using wearable devices (Birkler & Dahl 2014).

The actual use of consumer wearables within a clinical population is still limited, partly because of the fact that many applications are still in the early stages of development, and many have not been approved for medical use. Consumer wearables are overall still in a bit of a grey area, but in the future, if frameworks allow wearable devices to be integrated into health care systems this could kick-start the development of validation processes for a broader use of wearables. This would provide both individual and aggregated data for patients, governments, and health care providers (Piwek et al. 2016). The analysis of this data could play an important and vital role in how healthcare is practiced in the future. Moving forward, practitioners and researchers should try to work together and open a constructive dialogue on how to approach and accommodate these technological advances in a way that ensures wearable technology can become a valuable asset for health care in the 21st century (Piwek et al. 2016).

REFERENCES

Birkler, J. and Dahl, M.R., 2014. *Den digitala patienten*. Liber. 1st edition. Stockholm.

Evenson, K.R., Goto, M.M. and Furberg, R.D., 2015. Systematic review of the validity and reliability of consumer-wearable activity trackers. *International Journal of Behavioral Nutrition and Physical Activity*, 12(1), p.159.

Filkins, B.L., Kim, J.Y., Roberts, B., Armstrong, W., Miller, M.A., Hultner, M.L., Castillo, A.P., Ducom, J.C., Topol, E.J. and Steinhubl, S.R., 2016. Privacy and security in the era of digital health: what should translational researchers know and do about it? *American journal of translational research*, 8(3), p.1560.

Grossglauser, M. and Saner, H., 2014. Data-driven healthcare: from patterns to actions. *European journal of preventive cardiology*, 21(2_suppl), pp.14-17.

Health Data Exploration Project. Personal Data for the Public Good: New Opportunities to Enrich Understanding of Individual and Population Health. 2014. http://hdexplore.calit2.net/wp-content/uploads/2015/08/hdx_final_report_small.pdf Accessed September 26, 2017. Calit2, UC Irvine and UC San Diego.

Price, K., Bird, S.R., Lythgo, N., Raj, I.S., Wong, J.Y. and Lynch, C., 2017. Validation of the Fitbit One, Garmin Vivofit and Jawbone UP activity tracker in estimation of energy expenditure during treadmill walking and running. *Journal of medical engineering & technology*, 41(3), pp.208-215.

Kim, J., 2001. Phenomenology of digital-being. *Human Studies*, 24(1), pp.87-111.

Klonoff D.C., 2013. Twelve Modern Digital Technologies That Are Transforming Decision Making for Diabetes and All Areas of Health Care. *Journal of Diabetes Science and Technology*, 7(2), pp. 291-295.

Kostkova, P., 2015. Grand challenges in digital health. *Frontiers in public health*, 3.

Lee, J.M., Kim, Y. and Welk, G.J., 2014. Validity of consumer-based physical activity monitors. *Medicine & Science in Sports & Exercise*, 46(9), pp.1840-1848.

Lupton, D., 2016. *The quantified self*. John Wiley & Sons.

Nagtegaal, F., Verzijl, D., & Dervojeda, K., Probst, L., Frideres, L. & Pedersen, B., 2015. Internet of Things - Wearable technology. Business Innovation Observatory. European Commission. http://ec.europa.eu/DocsRoom/documents/13394/attachments/3/translations Accessed 2.9.2017

Omoogun, M., Ramsurrun, V., Guness, S., Seeam, P., Bellekens, X. and Seeam, A., 2017. Critical patient eHealth monitoring system using wearable sensors. In *Next Generation Computing Applications* (NextComp), 2017 1st International Conference on (pp. 169-174). IEEE.

Piwek, L., Ellis, D.A., Andrews, S. and Joinson, A., 2016. The rise of consumer health wearables: promises and barriers. *PLoS Medicine*, 13(2), p.e1001953.

Raghupathi, W. and Raghupathi, V., 2014. Big data analytics in healthcare: promise and potential. *Health information science and systems*, 2(1), p.3.

Redmond, S.J., Lovell, N.H., Yang, G.Z., Horsch, A., Lukowicz, P., Murrugarra, L. and Marschollek, M., 2014. What does big data mean for wearable sensor systems?: Contribution of the IMIA wearable sensors in healthcare WG. *Yearbook of medical informatics*, 9(1), p.135.

Salmond, S.W. and Echevarria, M., 2017. Healthcare Transformation and Changing Roles for Nursing. *Orthopedic nursing*, 36(1), p.12.

Shull, P.B., Jirattigalachote, W., Hunt, M.A., Cutkosky, M.R. and Delp, S.L., 2014. Quantified self and human movement: a review on the clinical impact of wearable sensing and feedback for gait analysis and intervention. *Gait & posture*, 40(1), pp.11-19.

Tjora, A., 2014. Digital Patients: A Typology of Emerging Patient Roles. In *PAHI* (pp. 135-144).

IBM Corporation. 2013. Data-driven healthcare organizations use big data analytics for big gains. *IBM Software White Paper*. Available at http://www.ibmbigdatahub.com/whitepaper/data-driven-healthcare-organizations-use-big-data-analytics-big-gains. Retreived 25.9.2017.

Wu, J., Li, H., Cheng, S. and Lin, Z., 2016. The promising future of healthcare services: When big data analytics meets wearable technology. *Information & Management*, 53(8), pp.1020-1033.

Xianqing, M., 2016. Digital skills for health professionals. In book: *Re-thinking european healthcare: Recommendations by the next generation*, pp.37-47.