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Digital health and digital biomarkers – enabling value chains on health data

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Abstract: Smart Devices, IoT and Co. are changing healthcare. The possibilities for pervasive sensing and analysis are fast increasing and new therapy concepts as well as business models are arising, related to the term “Digital Health”. The paper will give a brief overview on the history and ask, whether Digital Health is more than Telemedicine 4.0. Furthermore, we will ask for the prospective currency to participate in new preventive offer. Data is the new oil – Digital Biomarkers enable new value chains on health data and allow for the personalization of healthcare. We will present ongoing work of Fraunhofer ISST on a Digital Biomarker called beHealthy Health Score.

Keywords: digital biomarker; digital health; mobile health; pervasive sensing.

1 Introduction

There is a recognizable change in healthcare – IoT, Smart Devices, Big Data and Co. are changing the way of living a healthy life. Digitalization is the forthcoming term for the integration of technology in existing processes to foster their efficacy, efficiency and effectivity. Focused on health one is talking about Digital Health [1].

Technologies enabling pervasive sensing and analysis within the healthcare sector are fast increasing. Smart Watches and other Smart Devices increase the amount of heterogeneous data by being able to collect sensor data (e.g. motion detection, location-based services, Bluetooth-connected devices) at any time and any place. The pervasiveness of such technologies and the overall availability of data require the thinking of new data driven therapy concepts and business models to ensure high quality and efficient patient centred treatment. Data could have an enormous not quantifiable value to enable more patient-centered preventive and therapeutic offers [2].

Besides the potentiality of digitalization to change our way of thinking Becker et al. [3] pointed out, that a number of challenges need to be adequately addressed: From a psychological perspective, high attrition rates, digital divide of society, and intellectual capabilities of the users are key issues when implementing such technologies. Sriram et al. [4] completed from the technical perspective the necessity to ensure high data quality. But, from a user’s point of view data quality is an assumed requirement.

Within this paper we’ll give an overview on Digital Health, its definition and challenges to ensure high quality treatment. Later on the paper will introduce the term and meaning of Digital Biomarkers as a way to enable value chains and business models on health data. At last the paper will show case study results of beHealthy a PPG-based app to deduce a health score.

2 Digital health

A bird’s eye view into the history of the term Digital Health is required to answer the question: Is Digital Health some kind of Telemedicine 4.0 or even more (see Figure 1)?

Starting in the early 70s telematics was the leading expression for the fusion of telecommunication and informatics to exchange data between at least two different information systems. Focused on health the World Health Organization (WHO) introduced the term telemedicine as the “delivery of health care services, where distance is a critical factor […] using information and communication technologies (ICT) […]” [5].

As time went by, especially the distance as well as the data exchanging and consuming parties got discussed within the community. The usage of ICT shouldn’t be limited to the therapeutic parts anymore and the patient should obtain an active part within his treatment. As a conclusion the European Commission decided to introduce the term E-Health to pay attention to the increasing amount of ICT services for the improvement of prevention,
diagnosis, treatment, monitoring and management as well as the access to care and quality of care [6].

The ongoing establishment of mobile devices, e.g. smart phones, led to the definition of mHealth defined by the WHO as “medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices” [7]. Thus, “mobile Health” or “mHealth,” broadly can be defined as medical or public health practice supported by mobile devices [8], encompassing a variety of contexts: use of mobile phones to improve point of service data collection, care delivery, patient communication, use of alternative wireless devices for real-time medication monitoring, and adherence support [9].

Starting from 2015, the new term Digital Health tries to express the convergence of the digital as well as the genomic-proteomic revolution within healthcare, taking also everyday life and social aspects into account, like mentioned by Sonnier. The aim is to foster and increase the degree of self-responsibility of individuals for a healthy living. Furthermore, also aspects like efficiency, efficacy and effectivity as well as quality are taken into account to ensure a personalized and high-quality medical treatment [1, 10].

Regarding the question Telemedicine 4.0 versus Digital Health one can resume, that health and digitalization within the 21. Century are going far beyond the initial definition of telemedicine. Large and well known internet companies show how digitalization and data processing can turn health supply upside down. They are the key drivers for digital innovations using gadgets to realize self-reflexive and individualized preventive healthcare. Former patients are getting more and more customers, asking for digital health promotion solutions.

Thus, talking about Digital Health implies to talk about customers’ needs or business models. The actual German market survey of the D21 Initiative [11] shows an increased usage of digital products and digital infrastructures: 53.9% of the Germans over 14 years used mobile internet. Also the usage of mobile devices increased (tablets 2015: 35%, 2014: 28%; smartphones 2015: 60%, 2014: 53%). Many other analyses and forecasts have been realized by organizations like PwC, Frost & Sullivan as well as GSMA. With more than 6 billion mobile phone subscribers, it is estimated that 75% of the world population has access to mobile communication [7, 12, 13]. Probably more than a third or 500 million of the global smartphone users will have installed some type of mobile medical application in 2015 and it is expected that more than 50% of them have downloaded at least one mobile health application in 2018 [14]. In 2017 mHealth could potentially save a total of €99 billion (€69 billion on prevention, €32 billion on treatment/monitoring) in healthcare costs in the EU [12]. By 2016, there will be a projected 10 billion mobile devices in use worldwide [15]. The number of devices with broadband capabilities increased to more than 1 billion worldwide [13].

New preventive offers are more and more related to self-paying patients. But what would be the “currency”? Data is the new oil was postulated by Gerhardt [16]. In the following we’ll discuss the opportunity to use highly distributed, heterogeneous data for the deduction of Digital Biomarkers to personalize therapeutic offers and enable new business models.

3 Digital biomarkers

Today, the diagnosis and the follow-up within therapy are often accomplished by using well known time and money consuming biomarkers. They can be defined as objective, quantifiable characteristics of biological processes and have some relations to medical signs, symptoms, surrogate endpoints or clinical endpoints [17]. Looking at Digital Health and the usage of smart devices enabling a pervasive sensing of surrounding parameters like vital signs, there is an ongoing research on how heterogeneous data can be accessed to deduce equivalents to traditional biomarkers.

The increasing data volumes, the variety of data as well as the velocity of data input and output are typical challenges [18]. Bonnie [19] stated that healthcare data will explode from 500 petabytes in 2012 up to 25,000 petabytes in 2016, also forced by the extensive usage of IP-based devices. Nowadays, a forthcoming term to describe the increasing amount of heterogeneous data and the need for integrated data analysis technology is Big Data. There is no common definition of the term but Gartner proposed...
its 3V’s model to describe today’s situation in information society [18]: Increasing data volumes demand for new storage and analysis technologies. The challenge is to transform the variety of data available into decision supporting information and cope with the velocity.

The diversity of data types and information has the potential to optimize and personalize treatment or therapy concepts by identifying critical points for intervention. A detection of critical situations in earlier stages can result in a more easy and effective treatment [20]. With respect to biomarkers, the forthcoming term to bring relevant situations in health data and patients general conditions together is called Digital Biomarker. Great work on this term has been done by RockHealth within their article “The Emerging Influence of Digital Biomarkers on Healthcare defining Digital Biomarkers as “consumer-generated physiological and behavioral measures collected through connected digital tools” [21].

Traditional biomarkers like blood aim to determine a biological marker of illness whilst digital markers are more focused on the continuous assessment of phenotypic markers of illness. Digital Biomarkers can benefit from a longitudinal data collection, retrospectively processing the data to forecast possible critical or relevant medical situations. Furthermore, a digital system has the potential to react on a given situation in terms of intervention [20, 21].

The digitalization of health and the possibility to deduce relevant medical situations by processing data enables new business models. In Germany, a not inconsiderable part of health insurance are evaluating the usage of digital products to implement new reimbursement models. Data are striking promoters for new business models. Contrary to the value chain defined by Porter [22] a revision is needed to pay more attention to the data preparation process [23–25]. Furthermore, the patient or citizen wants to benefit from the monetization of his data [26]. Besides “willingness to accept” or “willingness to pay”, the immaterial subject “Data” should be materialized [27].

4 beHealthy health score

The ongoing work of beHealthy of Fraunhofer ISST is based upon the idea of aggregating data up to a single health score to realize a Digital Biomarker for the overall medical conditions [28]. To realize a pervasive sensing easy to use technology is required to measure e.g. vital signs like heart rate variability, blood pressure and resting pulse rate. A bunch of technologies like body-worn accelerometers are widespread used caused by a low financial entrance but any additional sensor a) costs money and b) has to worn every time or carried by the user. Fraunhofer ISST decided for the usage of photoplethysmography (PPG). PPG is a method that allows a low-cost and large-area health screening and a health assessment. It detects blood volume changes in the microvascular bed of tissue [29]. According to Tamura et al. [30] are red and infrared (IR) light-emitting diodes (LEDs) commonly used as the light source. The PPG sensor monitors changes in the light intensity via reflection from or transmission through the tissue. The changes in light intensity are associated with small variations in blood perfusion of the tissue and provide information on the cardiovascular system, in particular, the pulse rate. This concept offers a cheap solution to observe the vital signs of a patient 24/7. The combination of PPG and the smartphone boost is the ideal foundation for delivering vital signs for pervasive sensing and this creates new assignments, such as the prevention of stress disorders, the screening of risk groups or fitness optimization of athletes by themselves.

The beHealthy app (see Figure 2) allows the measurement of vital signs using PPG, connecting external sensors (e.g. pulse oximeter) as well as entering data manually (especially the subjective well-being). Methods of Machine Learning and Data Mining are used to identify patterns characterizing the health situation of a user bringing physical and psychological aspects together. Several parameters, e.g. Heart Rate Variability, are well-known to support the objectification of psychological states of a human being. With the actual state of evaluation we can show that PPG can be sufficient to approximate vital signs. beHealthy allows the measurement of equivalents for pulse, heart rate, HRV and blood pressure (pulse transit time).
Compared to certified medical sensors pulse and heart rate can be measured with a deviation of < 5%, HRV < 10% and blood pressure < 15% under controlled conditions (e.g. smartphone type restriction). Further work will focus on the optimization of the signal processing chain, especially to prevent noise during the measurement of blood pressure. Although the number of subjects to evaluate the correlation between objective and subjective well-being expressed as health score was limited to 10 persons (see Figure 3).

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