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SMART HEALTH

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Introduction

Health and long-term care consist mainly of services that are delivered in person to people in need. The sector is therefore not an obvious candidate for digitalisation, and indeed, it took quite a while for digital technologies to be adopted in everyday processes. However, the pace of transformation is very slow, and a lot of institutional obstacles seem to impede it further. This is deplorable, as without doubt, digital technologies have a lot to offer to patients, service providers and even informal carers. A very recent example is the difference in Covid-19 vaccine roll-out between EU countries that resembles a kind of natural experiment. In 2020, all EU-countries received the same amount of vaccine doses due to joint negotiations with pharmaceutical companies. Notwithstanding, countries like Denmark with a well-established digital platform, were much faster bringing the vaccine to people than other European countries because prioritisation could be performed on existing databases, and invitation to vaccination as well as appointment scheduling were digitalised. The same can be observed without the common starting point in Israel or the UK.

In this chapter, we will give an overview of how digital technologies change the shape of healthcare. As a starting point, we will first discuss the impact of digital technologies on the relationships between stakeholders that might help explain why implementation is not always smooth. We argue that digitalisation in healthcare has many benefits and the potential to increase effectiveness, efficiency and equity in healthcare delivery when implemented in a way that acknowledges its impacts on healthcare as a social system and includes professionals and patients in the implementation. However, applications in some areas are arguably more advanced than in others. In order to illustrate this, we will give examples from various fields that are representative of the current state of play. On the policy side, we will also investigate why it is difficult for digital technologies to take hold in healthcare systems.

Digital transformation of the healthcare system

Transformation processes in healthcare can impact the relationship between patients, service providers, insurers (or the organisation fulfilling the insurance function like a national health service) and the system as a whole. While some applications are targeted and therefore often
marketed to only one of these stakeholders, they will always influence the relationship with other stakeholders as well. Take an app for monitoring diabetes, for example. Even if it is used without connecting to service providers, it *empowers* the patients and gives them more control over their disease, thus impacting the relationship with their doctors. Another example is the use of big data consisting of health services linked with outcomes data. Such an analysis has the potential to reveal quality problems, which is important for insurers, regulators and also patients, but might be opposed by professionals.

It is helpful to use a diagram showing the main stakeholders and their relationships to better categorise digital solutions and also to deliberate the impact of transformation (Figure 29.1).

**Overview of applications at different stakeholder levels**

On the level of service providers, digital solutions include hospital information systems or medical practice management systems used to organise everyday processes and data. Such systems can be connected to an electronic health record or an electronic portal like *Sundhed.dk* (see later) on the level of the health system, but also to insurers to process payments or provide a portal to patients for them to exchange documents like clinical reports or to book an appointment. Service providers may also want to analyse their own data to improve processes and receive quality certificates, and even to market such achievements. They may also want to use telemedicine to improve the continuity of care. We will discuss this field in greater detail later.

*Insurers* might want to give their insurees the opportunity to manage their insurance contract online, submit invoices for reimbursement, find providers (sometimes called *navigation information*) and access information on the quality of providers or on other health-related topics. Such systems become increasingly smart by connecting different types of information in a context-sensitive way, such that a patient searching for information on their respective disease is also pointed to potential healthcare providers in their vicinity that offer specialised services for it, to apps for disease management for their smartphone and to chat forums in order to share experiences with other patients. There are also projects to make access even easier using chatbots like the primary care app *GP at hand* used by the National Health Service (NHS) in England, which we discuss further later. Both insurers and the health system as a whole also want to analyse data to improve their processes and generate evidence for their decisions.
At the patient level, the use of smartphone apps is widespread, as there is little regulation and firms often offer their apps for free in order to retrieve health data or to offer an upgraded paid version. Apart from simple applications tracking physical activity, mood or calories, several apps are now used as part of integrated care programmes. They sometimes carry the label serious health in order to set them apart from more wellness and free time-oriented apps. A review of the literature showed that under the right circumstances, such mHealth applications can potentially improve information sharing, self-efficacy and the relationship with the provider (Qudah and Luetsch 2019). Later in the chapter, we discuss mySugr as an example of the increasing applicability of this field.

A close connection exists to the research and innovation system in a country. Decision makers governing the healthcare system as a whole, insurers and also providers have their data analysed by universities and research institutes. Besides econometric methods, large data sets are increasingly investigated using artificial intelligence. An example of large data sets creating benefit for health systems is the OpenSAFELY platform, which uses the electronic health records of 40% of all patients in England. In a recent study (Williamson et al. 2020), data of over 17 million patients were linked to Covid-related deaths. It was thus possible to quantify the hazard ratios of serious Covid-19 for risk factors like diabetes, hypertension and also socioeconomic factors. Another example of an innovation in this field is the national Danish e-health portal Sundhed.dk, which we describe in greater detail in what follows.

Numerous other examples could be mentioned at all levels, and many of them span more than one, as is the case in telemedicine.

**Telemedicine and related concepts**

One of the largest fields connecting several stakeholders is e-health, which is an umbrella term for the utilisation of the internet and related technologies to deliver health services (Eysenbach 2001; Triberti et al. 2019). As visible in Figure 29.2, telehealth is a subcategory of e-health covering the use of telecommunication tools for exchanging health-related services and information. A form of telehealth is mHealth, which is the provision of medical care and public health
practice through mobile devices such as mobile phones, patient monitoring devices and other wireless tools (WHO Global Observatory for eHealth & World Health Organization 2011). Telemedicine is a subcategory of telehealth describing the remote provision of clinical services through telecommunication tools, i.e. excluding the provision of pure information or education. A remote provider contact is called a teleconsultation. Covid-19 has practically boosted this area, as it can help avoid physical contact, while current, widely available technologies such as smart phones allow for a stable audio–visual communication between providers and patients (Greenhalgh et al. 2018; Rockwell and Gilroy 2020).

Telemedicine is nowadays widely used in care for chronic conditions, which constitute the majority of today’s disease burden in high- and middle-income countries. In contrast to acute care, which is mainly provided by a single provider for a limited period of time (e.g. a hospital admission to treat erysipelas), caring for patients with chronic illness requires consultations with numerous providers at different occasions. It has been shown that continuity, coordination and timeliness of care are paramount to outcome quality in such cases (Czypionka et al. 2020; Kringos et al. 2010). Therefore, care for the chronically ill is ideally organised along predefined patient pathways. Such care is called integrated care, and use of digital tools is practically a sine qua non, regardless of whether integrated care takes the form of a disease management programme, a population health management programme or a public health management programme. Disease management programmes are coordinated healthcare interventions following an explicit structure and integrating several carers in chronic care, often using digital solutions as a support. Examples for disease management support services are the in-ear-sensor EPItech, the diabetes app mySugr and the remote monitoring and consultation programme TeleCare Nord, which are later discussed in more detail. Population health management programmes are set up to increase health outcomes for a specific part of the population (Swarthout and Bishop 2017), while public health management programmes are interventions rolled out to improve the health experience of the whole population (Hunter 2001). The electronic health platform Patients Know Best (see later) is an example of how population health management programmes make use of smart technology to coordinate their efforts. Within such programmes, providers exchange diagnostic and therapeutical data, monitor clinical parameters or consult with the patient remotely (Baltaxe et al. 2019). Examples for the effective utilisation of e-health in a public health management programme is the Danish platform Sundhed.dk and the primary care app GP at hand.

Very well-known examples of telemedicine include the Mercy Virtual Care Center (mercyvirtual.net) in St. Louis, USA. Founded in 2015, it once labelled itself “hospital without patients”, providing telemonitoring services and teleconsultation to patients and also expert advice to physicians who work in remote areas. Some countries, like Denmark, aspire to expand telehealth solutions throughout their healthcare system (Healthcare Denmark 2018). Their successful programme TeleCare Nord for COPD patients (discussed later in more detail) is being rolled out for other diseases like heart failure. Hospitals are supplied with the means to provide hospital-at-home solutions. The rationale behind hospital-at-home is the fact that hospital stays are expensive and at the same time tend to isolate the patient from their social support system. Providing the necessary technical equipment for their care, the patients’ parameters are monitored remotely when receiving e.g. chemotherapy or in cases of pregnancy complications. Necessary adaptions can be made by home care personnel, GPs or sometimes even by informal carers or patients themselves. Emergency situations can be predicted as well, allowing for hospital admission possibly even before critical events occur.

Telemedicine is also used in the field of rehabilitation, which aims to restore functional ability after an acute event or maintaining functions in a chronic illness. A recent study
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(Amorim et al. 2020) gives a good example of how new technologies can be harnessed for the benefit of patients. It reviews virtual reality-based serious games as a means to improve functional ability in stroke patients. In small-scale studies, this strategy has proved effective for improving upper limb functions.

**Technology in healthcare becomes smarter**

Besides telecommunication and standard information technology, increased computing power made new, “smarter” technologies available for use in healthcare. One major field is artificial intelligence, which is increasingly used in medical areas such as radiology, pathology or dermatology, where visual data can be analysed by software that uses pattern recognition e.g. with deep neural networks (Topol 2019). Concerns have been raised, however, about the black box nature of strong AI (Castelvecchi 2016). Under established clinical standards, diagnosis and therapy decisions need to be documented so that they can be reproduced in a transparent way. What is more, medical data are sensitive, underlying special data privacy requirements that are naturally anathema to black box type systems.

However, apart from the black box issue, further problems arise for the wider application of artificial intelligence in clinical medicine. For example, while the format and structure of relevant documents may be standardised in one location, it is probably not across several sites (e.g. hospitals), which limits the transmission of information generated by AI. Another challenge arises whenever natural language processing is used. Abbreviations can be very context sensitive or have different meanings in different specialities or even regions. E.g. “IM” can mean “internal medicine” but also “intramuscular”, “intramucosal” etc. Even with words and phrases there is a kind of jargon specific to different specialties in medicine or even local variants that are used in written reports and patient records, making them surprisingly difficult for machine learning to comprehend. For example, in the case of an admission to a hospital due to a heart attack, clinicians might use the words “myocardial infarction”, be more general using “acute coronary syndrome” or be more specific clinically using “NSTEMI” (non-ST-elevation myocardial infarction) or “STEMI” (the opposite) or refer to anatomical structures using “posterior myocardial infarction” (PMI). Adding to this complication, terms may mean different things depending on their position in the document, e.g. as a diagnosis as opposed to a complication that needs to be avoided. A recent study discusses such challenges in the context of gastroenterology (Nehme and Feldman 2020).

In neurology, artificial intelligence can help in multiple ways. With stroke, it can help perform risk stratification after minor forms (Chan et al. 2019) or help monitor atrial fibrillation together with mobile ECG in order to avoid embolisms (Li et al. 2019). Artificial intelligence can also support the analysis of electrical activities of the brain and help predict and avoid falls due to epilepsy, as in the EPItect project discussed later. In an ongoing project, a deep learning system is trained to diagnose Parkinson’s disease and essential tremor from hand movements and drawings (Varghese et al. 2019).

Artificial intelligence combined with robotics enable systems that understand the objects around them and take actions which maximise the likelihood of success to also endorse physical change in the world (Murphy 2019; Riek 2017). In healthcare, intelligent robotics can be used inside, on and outside the body of the patient, support doctors, formal and informal caregivers as well as provide decisionmakers with relevant information (Riek 2017). Robots are already used to perform micro-surgery like unclogging blood vessels and as smart prosthesis that are sometimes even more reactive than the original body parts. (Marius 2019). Furthermore, robots
can act as personal assistants for the elderly population by performing routine checks such as taking blood pressure and sugar levels, but also by conversing with them. Those robots sometimes come with the ability to analyse the personality and sentiment of the patients, which is especially helpful for people with mental conditions (Marius 2019). Service robots are used in hospitals to support healthcare staff by delivering items, restocking and cleaning.

Apart from improving robotics, artificial intelligence can also help analyse genomic sequences and their relation to disease, as has been shown e.g. in oncology (Shimizu and Nakayama 2020). Analyses of genomic material have become comparably cheap in recent years due to the rise of next generation sequencing techniques. Due to the sheer volume of data that this creates, strong AI systems have become indispensable in their analysis. While these are very helpful in research, they are increasingly used to support decisions in clinical medicine as well, e.g. to recommend therapies given certain mutations in cancers. Artificial intelligence is further used to make gene editing faster, cheaper and more accurate (Marr 2018). In the past years, several advances in the development of algorithms that predict repairs made to altered DNA have been reported, which in the future could improve research models to study genetic illnesses (Yeager 2019). Those models can subsequently be used for the development of personalised medicine, which is the creation of interventions that are tailored to a specific person or a genetically similar population. To date, this form of treatment is extremely costly, but automatic gene data analysis can significantly lower expenses that are necessary for the development of personalised medicine, such as predicting an individual’s chance to develop an illness or their response to a certain treatment (Marr 2018).

Another innovation that makes personalised medicine more realisable are 3D printing technologies, as it enables the creation of drug delivery services that are explicitly tailored to the patient’s need (Shaqour et al. 2020). The application of 3D printing in healthcare is mostly still in the research stage, but is apart from drug delivery services already used to produce surgical tools, guides and implants, external prosthetics or orthotics and tools for preoperative planning or simulation as well as medical education (Diment et al. 2017; Lau and Sun 2018; Tack et al. 2016).

The application of virtual reality in medical education to train and assess surgical skills has proven to be efficient (Pfandler et al. 2017) and has recently been extended to train healthcare staff in non-technical skills such as teamwork and situation awareness (Bracq et al. 2019). Currently, the ability of virtual reality to improve diagnosis and treatment of mental health conditions, to complement the management of Parkinson’s disease and to support rehabilitation of spinal cord injury is being explored (de Araújo et al. 2019; Rus-Calafell et al. 2018; Triegaardt et al. 2020).

Drug development is another field where artificial intelligence is increasingly used in a number of ways (Shaqour et al. 2020). Designing a drug needs an understanding of complex three-dimensional molecular structures and their change in shape under certain biochemical and physiological conditions. The strength of effect, toxicity and interactions with other substances can be simulated with the help of artificial intelligence. Computational drug repurposing or repurposing is an emerging field in which AI is used to increase the efficiency of data analysis to enhance the discovery of new applications for existing drugs (Park 2019). This method is for example used to accelerate the detection of treatments for Covid-19 (Zhou et al. 2020) and has been successful in identifying a drug for people with advanced pancreatic cancer that is currently being assessed in clinical trials (Fleming 2018). Existing drugs can be screened for possible application in new contexts (drug repurposing). Even the production process can benefit from predicting the yield of different synthesising procedures. These are just a few examples of this rapidly evolving area.
Examples

In order to illustrate the multiple ways in which digital and smart technologies are used in healthcare, we will present some examples of telemedicine for the aforementioned areas.

**EPItect**

EPItect is an in-ear-sensor that provides nursing support for people with epilepsy through sensory seizure detection. The device was jointly developed by cosinuss GmbH, Fraunhofer ISST and multiple experts for epilepsy. It was mainly funded by the German Federal Ministry of Education and Research (Epitect – Sensorische Anfallsdetektion 2016).

The device aims to solve three major problems faced regularly by people who suffer from epilepsy. First, few seizures are recognised early enough, meaning that carers cannot take safety measures in time (Baldinger n.d.). By measuring heart rate and blood pressure fluctuations, the sensor can anticipate seizures and automatically contact alarm services in case of critical attacks (Baldinger, n.d.). Consequences of injuries and premature mortality can thus be reduced (Epitect – Sensorische Anfallsdetektion 2016). Second, the documentation of epileptic seizures requires a lot of resources when done manually and is in many cases incomplete, incorrect or illegible, which complicates the prediction of seizures (Houta 2018). EPItect solves this issue by continuously and automatically collecting the patient’s health data (Epitect – Sensorische Anfallsdetektion 2016). The data is then both anonymised and used for further research and sent to the patient’s mobile app via Bluetooth, where personal information can be accessed anytime (Epitect – Sensorische Anfallsdetektion 2016). The availability of more precise data can be used as the basis for individual therapy decisions and scientific-pharmaceutical research. Third, the involved actors are currently not connected, which hampers efficient exchange of information that is needed to optimise care (Epitect – Sensorische Anfallsdetektion 2016). To increase the accessibility and the exchange of information, a web portal for the carers was developed, on which treatment and therapy plans of the patients can be monitored at any time. When used properly, EPItect has the ability to increase patient autonomy as well as the quality of life and a sense of safety for both carers and patients (Epitect – Sensorische Anfallsdetektion 2016).

In practice, the in-ear-sensor needs to be improved further according to users, because the battery power is too low, the appearance of the in-ear-sensor is perceived as too visible and the device impairs hearing. Additionally, users reported discomfort connected to wearing the sensor, like increased stigmatisation, a feeling of surveillance and constant reminders of one’s own illness (Houta 2018).

The accuracy of seizure detection is currently 40%, but may increase if more data is gathered (Baldinger, n.d.). However, users criticised that even if the seizure is correctly diagnosed, the notification is given only shortly before. Therefore, despite the limitations and problems caused by the sensor, seizures still persist and sometimes help comes too late (Houta 2018).

**MySugr**

MySugr is a certified medical device that supports users in the dosage of insulin and facilitates the documentation of all diabetes data. The app was developed by four entrepreneurs in 2012 and acquired by Roche in 2017 (About Us | MySugr Global n.d.; Roche Acquires mySugr 2017). Since then, patients can order a starter-kit when signing up, which in addition to access to the app and online coaching includes unlimited test strips, a blood glucose meter and a
lancing device made by Roche. At the moment, there are more than 2 million registered users (mySugr – Diabetes Tracker Log n.d.).

The device aims to simplify the lives of diabetes patients by quickly gathering their therapy data on their smartphone. This is achieved by connecting the blood glucose meter with the smartphone via Bluetooth, where patients can access and analyse their own values to identify patterns more easily. In addition, the app is equipped with a diabetes diary and an insulin calculator and gives access to diabetes advisors that provide assistance between visits to the doctor (Diabetes App, Blood Sugar and Carbs Tracker | mySugr Global n.d.).

MySugr can be purchased individually from the medical devices made by Roche, since various blood glucose meters from different manufacturers can be seamlessly integrated (Kukla 2018). Also, patients are provided with a demand-oriented supply of test strips, whereby both the calculation of the test strip consumption and its dispatch directly to the patients is carried out automatically (Diabetes Bundle All-in-one Package | mySugr Global n.d.).

Research has shown that apps can in general support changes in lifestyle and glucose monitoring for people with type 1 and type 2 diabetes (Kebede and Pischke 2019). A study evaluating mySugr found that blood sugars significantly decreased for high-risk patients and that low blood glucose indices were reduced (Debong et al. 2019). In addition, a reduction of estimated average blood sugar levels over the past three months (eHbA1c1) and improved glucose control was observed (“Science & Research | mySygr Global” n.d.).

Patients seem to be satisfied with the product, as the app received a user experience rating of 4.7 out of 5 stars based on 8,000 evaluations (Diabetes App, Blood Sugar and Carbs Tracker | MySugr Global n.d.). Kebede and Pischke (2019) evaluated multiple diabetes apps and found that mySugr was the most popular one.

This stands in contrast to a usability evaluation of commercially available diabetes apps of Fu et al. (2020). The researchers tested individual app functions and found that mySugr has the most shortcomings compared to the apps OnTrack Diabetes, MyNetDiary and Glucose Buddy. MySugr had the greatest number of violations of heuristic principles, especially in the area “Help and documentation”, followed by “Error prevention” and “Aesthetic and minimalist design”. Examples for those detected deficiencies are that the help function was unavailable or not easy to use or that the screen was too busy (Fu et al. 2020). The authors also criticised that mySugr lacked a blood glucose analysis report sorted by meal, which is necessary to support patient autonomy when modifying meals. However, all diabetes apps were rated poorly by the authors and in their opinion needed improvement in user friendliness.

**GP at hand**

GP at hand is an app which supports the provision of primary care. Patients can write requests to a chatbot that delivers context-sensitive information, and if the problem is more serious, a practice nurse is connected via video conference (“Product” n.d.). The app was developed by Babylon Health and integrated into the British National Health Service (NHS) in 2017, meaning that patients covered by the national health insurance can use it for free. The service has expanded rapidly over the past two years and has currently more than 90,000 users (“Why choose us” n.d.).

1 HbA1c is a parameter for monitoring the effect of elevated blood glucose and its levels are a good proxy for therapeutic success as well as for prognosis of organ damage. With continuous measurement of blood glucose, this parameter can be estimated (eHbA1c), reducing the need for additional blood sampling.
The key innovation of the service is the development of an AI system that can read, understand and learn from anonymised and consented medical datasets, patient health records and consultation notes (“AI” n.d.). This information can be used by healthcare staff to make faster decisions based on more accurate information about triage, causes of symptoms and future predictions of health. As a result, the process is speeded up and capacities are freed to see more patients. The AI system also supports patients to address symptoms and get faster information about diseases (“AI” n.d.).

The app was created to give more power to the patient by increasing the accessibility and affordability of healthcare (“About” n.d.-a). Compared to traditional GP services, consultations through GP at hand are available around the clock every day of the year, which lowers the barriers to attending appointments. Online appointments are available within hours or days (“How we work” n.d.), and if patients need services like vaccinations that definitely cannot be done over the phone, they can book an appointment through the app (Rachael 2018).

In case a doctor prescribes a medicine after an online consultation, the prescription is sent via the NHS online service to a pharmacy that is near the patient, where it can be collected (Noble 2018). Consultations are recorded, meaning that patients can replay the video, which is especially helpful for patients who have difficulties with hearing or remembering information (“How we work” n.d.).

The app currently has a satisfaction score of 96% based on 40,300 ratings (“Babylon” n.d.). However, the proportion of patients that deregister is 28%, where half of them returned to their original office (Burki 2019). Although GP at hand simplifies consultations, experts are concerned that this way of delivering service is not sustainable in the long run, as it leads to “cherry-picking” patients, where younger and healthier patients use GP at hand and older and more deprived patients are left to traditional GP facilities (Crouch 2017). Crouch (2017) points out that this development will increase the pressure on GPs, who already suffer from staff shortage. In addition, an evaluation of the service has shown that although the patient group using GP at hand is generally healthier compared to the rest of the population, the usage is higher (Iacobucci 2019). This could be caused by supplier-induced demand, meaning that the easy access to appointments generates unsustainable health-seeking behaviours. Another explanation is that people who could not keep a doctor’s appointment before have now the possibility to receive consultations (Burki 2019).

Sundhed.dk

Sundhed.dk is the national Danish e-health portal that provides access to personal health data of hospitals, general practitioners and communities as well as general information about health-related topics. It is part of the public health sector and its strategies, and was therefore developed and funded by different governmental institutions (Jensen and Thorseng 2017). The portal is used by 1.7 million citizens each month and is the most used application among healthcare providers in Denmark (Petersen 2018).

The aims of the portal are to support general practitioners in Denmark in their function as “gatekeepers” of the healthcare system, to increase the self-determined involvement of patients, to promote cross-sectoral and integrated care and to provide coherent care across the national, regional and local level. Health service providers can use the portal to access their patients’ health data. Citizens can access their medical records and medication but are also provided with quality-assured information about health topics and an overview of the Danish healthcare system. Patients can book doctor’s appointments via the platform. Furthermore, the data that is
collected is also used to inform decisions about future investments, strategies and solutions for healthcare services (Jensen and Thorseng 2017).

It is not the purpose of Sundhed.dk to create data, but rather to present already existing data extracted from data sources such as hospital information systems, practice information systems, prescription databases and lab systems. It also integrates other healthcare services, such as booking of doctor’s appointments. These services can be located and run somewhere else (Jensen and Thorseng 2017). The platform can be accessed by the national electronic identifier scheme (NemID), which is a common secure login that is also used to access online banking or tax files (“Introduktion til NemID – NemID” n.d.).

The portal empowers patients by providing them with transparency, supports healthcare staff, facilitates communication between patients and healthcare providers and supplies decision makers with relevant information. According to the CEO of the platform, Danish society is well aware of problems regarding data security, but considers those benefits to be higher than the risks of damage through a possible hacker attack (Petersen 2018). Danes have in general lower data protection concerns and are less concerned about contact with the industry. Since it is normal to make health data available, it is not possible to opt-out of the e-health portal (Petersen 2018).

Results of a study evaluating differences in electronic health literacy between users and non-users of the platform showed that there are no differences regarding age, sex, educational level and self-rated health (Holt et al. 2019), indicating that the platform has a high user-friendliness, which is important considering that 36% of the users are above 60 years old and that this amount will rise in future. Other upcoming obstacles are keeping the platform up to date, as the rapid development of health technologies constantly creates further features that need to be implemented (Jensen and Thorseng 2017).

Patients Know Best

Patients Know Best is a patient-controlled electronic health record developed by a social enterprise (“About” n.d.-b) and funded by the British National Health Service (NHS) (“Commissioners and Payers” n.d.). The platform has newly expanded to other European providers and is also available in Germany and the Netherlands. Currently, it is used by 8 million people, which makes it the most widely used patient-controlled electronic health record in Europe (“Carepoint” 2020).

The platform combines personal health data such as test results or entries in a health diary with information provided by the healthcare staff, like appointment letters and multidisciplinary treatment plans. Patients always have access to the data, but can decide if and how much they want to share with health service providers or family and carers (“About” n.d.-b). It is especially helpful for people suffering from multiple conditions who often need treatment in several facilities, but can be used by any patient.

The aim of Patients Know Best is to provide patients with a tool to become more active in managing their health and wellbeing, to enhance patient-centred care and to increase safety and efficiency among healthcare providers (“About” n.d.-b). If a patient seeks care at a new facility, the staff will have insight into the patient’s medical history and can therefore build a better understanding of what type of care is needed. This is especially helpful during emergencies (“The Personal Health Record Founded for Patients” n.d.).

When the impact of the platform on patients, clinics and financial resources was evaluated, benefits that arise by using Patients Know Best could be found in all of those areas (Gamet et al. 2016). Clinical outcomes were improved and reductions of waiting-times and non-attendances
of doctor’s appointments could decrease costs substantially. Compared to similar services, *Patients Know Best* has the highest participation rate, which after the authors can be explained by the fact that it was not built around a particular group of patients and that it is useful for both healthcare professionals and patients (Gamet et al. 2016).

The results of a different study analysing *Patients Know Best* found that, contradicting common assumptions, only a minority of patients who were offered to use the service showed interest in taking more responsibility for and control over their health management. Furthermore, the willingness to use the platform depended on the patient’s coping style (Schneider et al. 2016). The authors criticised that it is not enough to “activate” patients and suggested the service be improved by including this and other patient attributes.

**TeleCare Nord**

*TeleCare Nord* is the common telemedical healthcare service in Northern Denmark. It currently offers monitoring for people who suffer from heart failure or chronic obstructive pulmonary disease (COPD). The service was developed by 11 municipalities in North Jutland, general practitioners and Aalborg University. It was funded by different private and public Danish funds and the EU Social Fund (Udsen 2015).

The system is an integral part of the health service in North Jutland, where citizens with COPD can be referred to telemedical home monitoring via a general practitioner or the hospital (“Telemedicin til borgere med KOL” 2020). The aim of the program is to increase the safety of patients by simplifying monitoring of their condition. It is expected that timely interventions decrease hospital admissions, which saves costs in the long run (“Til patienter og pårørende – KOL” 2020).

When patients are referred to the program, they receive a TeleKit which includes a tablet and measurement equipment used for measurements of oxygen saturation, heart rate and blood pressure (“Til patienter og pårørende – KOL” 2020). The data is sent from the measuring devices to the tablet via Bluetooth. There are two apps installed on the tablet. One of them, OpenTele, contains questionnaires about patients’ health status, displays measurements from the devices and gives access to a message function which enables communication with the health professional (Udsen 2015). The other app is called OpenTele Info and contains a digital user guide, videos about how to use the equipment and training videos tailored for COPD patients.

The measurements are also sent to the regional care centre or the hospital, where the healthcare staff monitors the parameters. If these change, medical personnel will assess with the patient if the treatment needs to be adjusted or if additional interventions are necessary (Udsen 2015).

A study assessing *TeleCare Nord* showed that 88% of the participants found the TeleKit very easy to use and that citizens were in general very satisfied with applying telemedicine (Udsen 2015). The patients reported several advantages of using the system, such as a better control of the disease, an increased feeling of security, higher awareness of their own symptoms, more frequent responses to exacerbations and a higher level of freedom. In addition, the blood pressure of patients using *TeleCare Nord* dropped significantly compared to the control group (Udsen 2015).

Since the results of the project were positive, the local governments and Danish regions have decided to extend the service to COPD patients in other parts of the country (“Forskning viser positive resultater for TeleCare Nord Hjertesvigt” 2020). Furthermore, the system is currently tested on patients with heart failure, but the permanent integration is still debated (“Nordjyske patienter med hjertesvigt får fortsat tilbud om telemedicin” 2019). An assessment of *TeleCare Nord* as an add-on to the standard of care for patients with heart failure showed that
it was highly cost-effective, as there were significant reductions in expenditures for hospitalisa-
tion and primary care contacts, as well as a decrease in total costs (Vestergaard et al. 2020).
Additionally, patients who were referred to the program reported that they feel safer when they
are monitored between consultations and after leaving hospital, which increases their mental
health and thus their quality of life (“Nordjyske patienter med hjertesvigt får fortsat tilbud om
telemedicin” 2019).

Socioeconomic implications

We can see that digital technologies have changed healthcare delivery in numerous ways so far.
Efficiency and effectiveness of healthcare delivery may be improved. But what does the digital
transformation mean for equity in healthcare?

Indeed, the literature shows that e-health may increase access to care, reduce healthcare
costs and simplify self-management (Wynn et al. 2020), which has the potential to improve
health outcomes for underserved populations, the elderly and citizens of low- and middle-
income countries (LMICs). In high-income countries, people who live in remote areas, have
low income, low education or immigrant status or are of high age often lack adequate access
to healthcare and are therefore referred to as underserved population (Chesser et al. 2016).
E-health could increase their access to services, as individual costs may decrease, while the
amount of services offered may rises (Wynn et al. 2020). However, disadvantaged communi-
ties usually have lower levels of e-health literacy (Chesser et al. 2016), meaning that they lack
digital expertise to seek and apply health knowledge via electronic sources to address or solve a
health problem (Norman and Skinner 2006). Therefore, additional interventions such as provi-
sion of devices and support in using them are necessary until the benefits of e-health reach the
underserved population, which in turn has led to concerns about increasing inequity due to
differences in digital literacy (Azzopardi-Muscat and Sørensen 2019).

The elderly population uses the healthcare system most frequently and could therefore
benefit immensely from e-health interventions that lower the barriers to access (Vancea and
Solé-Casals 2015). Additionally, societal costs can decrease significantly if access to electronic
self-care programmes is increased. However, the elderly often struggle with using complex
devices compared to younger generations (Ziefle and Bay 2005) and are significantly less likely
to use the internet compared to the average population (Niehaves and Plattfaut 2014). Until
now, many health apps have failed to accomplish their goal of supporting self-care for the elderly
because of their complicated design (Vancea and Solé-Casals 2015), which can be partially
explained by the age gap between the users and the developers (Hawthorn 2007). To increase
user-friendliness and therewith the efficiency of e-health applications for the elderly popula-
tion, researchers suggest including the older generation during the development of e-health
interventions (Hawthorn 2007; Vancea and Solé-Casals 2015).

E-health has the potential to increase the provision of healthcare in LMICs, where the dis-
tribution of providers is often poor and staff shortages are common (Schweitzer and Synowiec
2010). An essential driver of this development is the increasing supply of mobile devices to
remote areas and LMICs (Mechael 2009; Schweitzer and Synowiec 2010). Positive outcomes
caused by the use of e-health in LMICs include higher adherence to drug regimes, increased
efficiency of healthcare workers and remote delivery of healthcare services and information
as well as the facilitation of data-based budgeting practices (Elder et al. 2013; Schweitzer and
Synowiec 2010). Negative consequences could be an increased workload for healthcare staff and
delays in service delivery due to bottlenecks in training (Elder et al. 2013). Furthermore, there
is still limited evidence about the cost-effectiveness of e-health, which is necessary to inform
future investment decisions (Fritz et al. 2015; Lau 2017; Schweitzer and Synowiec 2010). This uncertainty hampers the introduction of e-health in LMICs, where resources are significantly more restricted compared to high-income countries. It is likely that, as with many technologies in healthcare, the potential recipients need to be stratified in order to identify groups for which the benefits outweigh the costs.

**Reasons for slow pace of transformation**

While we hope to have illustrated the benefits of digital and smart technologies in healthcare, it is surprising that the actual adoption in healthcare systems is comparably slow. Indeed, numerous obstacles can be identified on different levels. We will discuss them one by one, but they also interact with each other, contributing to the phenomenon.

**Health systems are complex social systems**

In healthcare, numerous stakeholders interact with each other. They have developed rules of interaction over time that are adopted by individuals by following them over and over in their everyday dealings. In the social sciences, this process is called *habitus formation* and the summative result are *institutions*, i.e. the sets of rules that structure social interactions. Such institutions stabilise a social system but also change slowly. Implementation of new processes, as is the case in smart technologies, tends to disrupt these institutions, creating a reaction and requiring legitimisation (Hinings et al. 2018). While the phenomenon of *institutions* and *disruption* is present in other sectors as well, the degree of complexity seems to be higher in healthcare (Martínez-García and Hernández-Lemus 2013).

**Large parts of health systems are not market-oriented**

Many European countries organise their healthcare systems with a strong reliance on public financing or even public provision. Even when provision is private, it is tightly regulated due to quality and equity concerns, but also prone to rent-seeking behaviour by professional organisations (Tuohy and Glied 2011). Thus, many of its moving parts are not exposed to market forces, and therefore the need for process innovation in general is low. This is the reason why so many countries have experimented with more market-orientation, most notably the Netherlands with their managed-competition approach.

While the absence of competition can reduce the adoption of new technologies, countries may also opt explicitly to foster digital solutions on a central level, like Denmark or the UK. It bears mentioning that there seems to be a cultural divide concerning the topic of digitalisation that we will explore further later. Compared to these cultural aspects, financial issues seem to play a minor role; while Estonia is strong in digitalisation, Germany and Austria are lagging behind.

**Rigidity in public health systems**

Another reason complementary to low competition is the rigidity of regulation in healthcare, which is an obstacle to digitisation (Meskó et al. 2017). In political economy, there is a constellation often called an *iron triangle*, i.e. a rather rigid relationship between legislation, payers and providers (Buse et al. 2012) that hinders innovation. As in public healthcare systems, there are normally few real market prices but rather fee schedules that are negotiated between payers and provider representatives, often subject to tight regulations; introducing digital solutions that go
beyond e.g. a practice management system will need to be reflected in such a fee schedule. The question then arises whether this solution will reduce or increase costs for the provider and thus requires an increase in fees, and to what extent. Risk-averse payers, even more so without competition for insurees, will naturally be hesitant given that revenue will not increase, in line with legislators and providers seeing little gain in change. This problem is exacerbated when cost-effectiveness studies yield ambiguous results, which is not uncommon given the complexity of digital solutions and their impact on health systems.

**Fragmentation in healthcare**

Many healthcare systems suffer from fragmentation between sectors, service providers and insurers. This problem has become more prominent with the shift from acute disease to chronic disease, the latter requiring several providers and payers working together along the patient pathway, while organisational setups often vary between and within providers and payers. While digitalisation can help mitigate the problem, this requires several stakeholders to agree on standards, interfaces or common platforms. In his seminal work, Leutz formulated five laws of integrated care, one of which reads “your integration is my fragmentation” (Leutz 1999), which can easily be applied to digitalisation as well. If a consortium of providers like in the Dutch chronic care programmes decides on one joint system, other providers that use a different system may be excluded. Agreeing on standards while keeping up competition and innovation is therefore an essential task for health policy.

**Data privacy and transparency**

Much of the data in healthcare falls under the special category of personal data according to the General Data Protection Regulation (GDPR), i.e. is very sensitive in nature. This alone explains why establishing digital processing of such data requires time and the implementation of strong safeguards. While the technical aspect seems to be more or less under control, there is also the aspect of trust on the individual and societal level. The black-box nature of some AI applications does not help make things easier in this respect.

Different countries seem to have different approaches to this. While some like England or the Scandinavian countries seem to embrace digital solutions in healthcare more easily, Central and Eastern Europe seem to be more cautious. It is likely that societies put different weights on disadvantages like possible data breaches, on the one hand, and benefits like improved continuity of care, on the other. Policy makers therefore need to acknowledge people’s need for data privacy and explain carefully the advantages and safeguards repeatedly. It seems advisable to actively and openly discuss the possibilities and risks of data breach or misuse of data.

Notwithstanding, digital solutions unequivocally increase the transparency of healthcare delivery. With a good electronic health record, it is theoretically possible to assess the quality of different ways of healthcare delivery from diagnosis to therapy, but also of individual healthcare providers. In a “blame and shame” culture, such providers may be opposed to increased transparency through digitalisation.

But even when there is a culture of continuous quality improvement and learning from mistakes, digitalisation means a paradigm shift for healthcare providers. Patients that are “in control” of their disease through digital platforms, mHealth applications and self-help chat-groups are a completely different counterpart to health professionals. Thus, digital solutions can also redefine the whole physician–patient relationship, and health professionals may need support in adapting to new roles.
Marked differences between countries also exist in terms of health literacy and digital literacy, often jointly referred to as e-health literacy or digital health literacy (Quaglio et al. 2017). Without sufficient digital health literacy, patients may not feel comfortable using digital solutions or having their health data digitally processed. Without increasing digital health literacy, digital transformation of healthcare may fail to yield expected results and give rise to a decrease rather than an increase in health equity (Azzopardi-Muscat and Sørensen 2019).

Conclusion

The digital transformation of healthcare has an impact on nearly all relationships between stakeholders and levels of care, but the speed of implementation in healthcare falls short of the speed in other sectors. We explored several possible explanations for this phenomenon, and in order to facilitate further change, decision makers may want to give these a closer look.

According to the literature, smart health in its various forms has the potential to increase effectiveness, efficiency and also equity in healthcare delivery – given the implementation is accompanied by measures ensuring the acceptance by professionals and patients alike. It is a sine qua non in efforts to integrate chronic care but affects many other areas as well. We can see that the maturity of solutions varies by field. While there exist powerful information systems and telemedicine applications, there are still e.g. challenges for artificial intelligence to grasp the complex contexts in medicine.

The Covid-19 pandemic made it very obvious that the pace of digital transformation varies widely between countries. Various reasons can lead to slow adoption of digital solutions in healthcare. It seems vital to understand the institutional fabric of a country’s system in order to facilitate digital transformation. Without paying heed to the specific layout, and possibly changing some regulation, digitalisation can face considerable resistance by stakeholders and is affected by all factors that also hamper innovation. Successful implementation therefore hinges on the careful inclusion of people affected, i.e. patients and professionals alike, but also e.g. administrative personnel. Ethical and data protection issues seem to be valued differently in different countries, contributing to variations in uptake speed, so broad and upfront public discussions are needed. It seems clear that – as with all other industries – digital transformation leads to disruption of traditional roles and relationships. This needs to be acknowledged and it is an important task for health policy to manage such issues. Lastly, for people being able to make use of digital solutions and avoid inequitable access to healthcare, digital health literacy needs to be increased across the population. Thus, numerous control knobs need to be turned in order to pave the way for a successful digital transformation of healthcare.

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