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SMART HEALTH TECHNOLOGY

THE NEXT STEP IN HEALTHCARE
TECHNOLOGY

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DESCRIPTION OF SMART HEALTH TECHNOLOGY

While Data Analytics enable IT-systems to deliver tailored advice based on advanced analysis, the analysis will only ever be as good as the collected data. With recent advances in the development of health technology, we are seeing pervasive technology within healthcare which empowers citizens, patients and healthcare professionals to obtain and engage with various kinds of data related to personal health and wellbeing, as well as the operations of the healthcare system in general. The trend of recording especially personal health information has been steadily growing for several years with the notion of the Quantified Self. This movement has seen a steep increase in recent years as the rising abilities of IT and decrease in cost has made a wide variety of Health Technology available at an ever lowering cost. As presented here, the current state of Smart Health Technology is, while advanced, in its relative infancy as the trends which have been carrying the movement forward is said to converge with the areas such as Data Analytics.

DEFINITION

Smart Technology is an umbrella term covering all forms of technologies which has (1) physical sensors with which to register data from its surroundings, (2) storage and (3) computational capacity with which to store and analyse the data, as well as (4) the means to deliver either actionable advice tailored to the end-user or automated actions, based on the data input. Smart Health Technology adheres to the above definition, with the clause that it is used with the purpose or, or within the domain of Health and Well-being.

Smart Health Technology is believed to cause drastic changes over a short period of time in the capabilities of wearable health technology as well as provide an opportunity to of incorporate both health data from private citizens in near real time, as well as monitor the status of various kinds of Smart Health technology within the hospital. This latter aspect will give rise to Intelligent Operations and Maintenance in which the notions of prevention rather than reaction to disease will be mirrored in the way that hospitals and medical institutions engage with internal processes and maintenance of increasingly complex technology.

“Attention is being focused on wearables but I believe that the use of sensors and robotics will start cracking through in the next seven years. We’ll see sensors in individual devices as well as for remote monitoring, and while these will not be fully distributed they will be commonplace” (Wolf, 2018).

These changes are however not without required changes to the fundamental nature of the Healthcare system and it’s interaction with citizens, patients and healthcare professionals. As presented below, it is noted that, as citizens adapt and incorporate ever more detailed sensor-technology to record their own health and wellbeing, the hospitals are at risk of losing non critical healthcare-issues of their users to more agile organisations which actively incorporate this data in a smart and meaningful way. Critical, emergency and GP-tasks will however likely remain in their respective domains.

WHAT IS SMART HEALTH TECHNOLOGY?

The notion of ‘Smart Technology’ often connotes some form of automated analysis of data and, centrally, the presentation of results from this process in a manner readily understood by the end-user.



In combination, the notion of Smart Health Technologies encompass those technologies which enable users to record health information from increasingly advanced sensors, store and compute these automatically and deliver either personalised advice or automated actions from the collected data. As such, Smart Health Technologies are at least in part physical, and can include the means to interact and engage with the data by way of e.g. Virtual or Augmented Reality as well as other forms of data representation.

The range of Smart Health Technologies is quite wide, and despite the term lending itself more to consumer products, the term includes for instance enterprise products such as internet connected (IoT) backboard of a MR-scanner at a hospital which enables Intelligent Operations and Maintenance. The MR-scanners IoT-connected capabilities allow the system to notice if a part is worn out before an incident occurs. It can then automatically transmit a message to delivery-robots who transport a replace-

ment part from storage to the needed location for human inspection and implementation before use. In this scenario, the worn-out component, the message system and the robot are all part of the Smart Health Technology which uses sensors and computational capabilities to identify and analyse the environment before offering actionable advice or as in this case takes automated action to remedy the situation by transmitting the appropriate instructions to a robotic drone.

“Examples of IoT-enabled applications are remote monitoring and control of homes, and personal health and fitness tracking. By 2025, the IoT is expected to encompass 0.5-1 trillion devices - with a potential economic impact of 2.7-6.2 trillion USD annually”(DNV GL, 2017, p. 32).

WHY IS SMART HEALTH TECHNOLOGY RELEVANT?

As hinted in the above, the true relevance of Smart Health Technology lies in convergence with other burning platforms and major developments such as Data Analytics. The relevance of this is measured by its value to users: Citizens, Patients, Healthcare personnel, the Healthcare Sector and society as a whole; but the relevance is driven not by the technocratic approach of wanting to implement technology in everyday devices, but rather legitimate demographic changes.

“Globally, the “number of hospital beds are fundamentally declining on a per person basis and we also have a growing Silver Tsunami, if you would, of people who are retiring, across every single industrial country, especially in the European market and the United States” (Jylling, 2018).

Indeed, the developments of Smart Health Technology is in many ways both the result of convergence of the areas mentioned above, as well as the need recurring needs of optimization within the Healthcare Sector which is seeing a “Silver Tsunami” in the growth of elderly persons. This provides especially companies engaged in Health Technology with the opportunity to benefit from this “Silver Economy” (“Smart Silver Economy’, 2018) by providing products and services that address challenges fostered by demographic changes.

Given these changes, the advances of technology have already been adopted to assist in providing care and wellbeing for persons in need for several decades. The true relevance of Smart Health Technology over these previous initiatives comes in the changed nature of the devices which will be developed.

“If every time you smoked a cigarette your fingernails turned black and a black spot appeared on your forehead, indicating how much damage you were doing to your lungs, heart and circulatory system and to your DNA, then we might change our behaviour. Looking for technologies which can provide a short feedback loop and give us an understanding of the impacts of our lifestyle and behaviours and other long term aspects will be interesting in the next 10 years”(Dean, 2018).

HOW IS SMART HEALTH TECHNOLOGIES DONE?

The use of sensors in self-monitoring has long been the cornerstone of the notion of Quantified Self. When these aspects of recording various states of personal health for personal use are combined with increasingly advanced sensor as well as advanced Data Analytics, Smart Health Technology will be able to encompass the use of both sensors dedicated devices which record health-data and engage with this in engaging and increasingly more customised ways. Looking to 2025 and beyond, there is no indication that this will decrease. In fact, with the advantages of advanced machine learning it is likely that health systems will provide users with predictive recommendations based on their lifestyle as recorded through several different data-sources which all provide a multitude of data points. Imagine a system which could recognise items and amounts of different foods based on photos, paired with fitness-tracking, sleep-logging, blood type information and medical records. Such a system could deliver increasingly tailored recommendations to user's diet, based not on calorie-intake alone, but include vitamin-levels and nutritional values, as well as account for personal preferences found by cross-referencing a large dataset on how the user sleeps, eats, behaves and performs throughout their day.

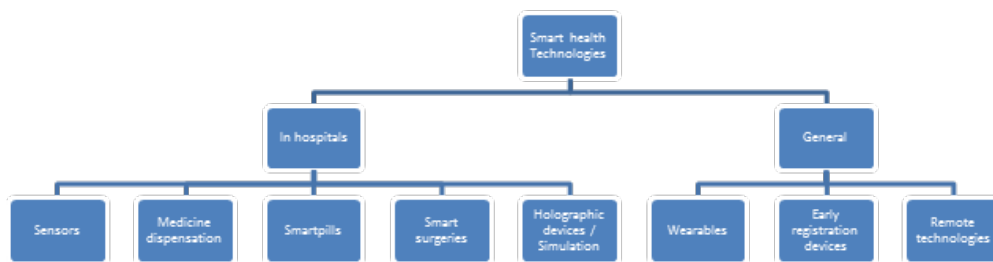
The availability of both real time and historic health data will allow users to engage in more detailed analysis of their health and wellbeing, and will allow health-care professionals to potentially access a wide array of supporting information for diagnostic purposes. However, the crucial point of interest is the reliability of the sensing environment. As several experts state in this report, the current state of the art in Smart Health Technology is in its infancy and the reliability of the data is not high enough that healthcare providers or end-users can rely on the precision, reliability and accuracy of the data.

“Once this gets fixed and we have done some clinical trials to show that one kind of wearable device actually delivers trustworthy data I think this will be integrated into our electronic health records and become part of the decision support that clinicians draw diagnostic information from” says Jonas Moll (Moll, 2018, 24:40).

While the present developments in Smart Health Technology is still simple in their nature and ability to record and store information, we will see more advanced solutions being developed in the near future, as the advances in mobile data-sharing is rising with the advances of 5G data transfer which enables data transfer rates faster than 1Gbps and will enable even highly complex data-streams to be transmitted for remote processing with responses on patients state of health received virtually instantaneously (DNV GL, 2017, p. 32).

SMART HEALTH TECHNOLOGY IN THE DANISH HEALTHCARE SECTOR

As described above, the start of the art in Smart Health Technology is showing great potential, and while there are good examples of both Danish and



FIGUR 1: OVERVIEW OF MISROSOFTS SMART HEALTH TECHNOLOGY PROJECTS BY NIALL MCDONAGH. FOR MORE SEE (MCDONAGH, 2017, 20:00-27:02)

TODAY

According to the Danish Institute for Local and Regional Government Research which was previously known under the name KORA and is now called VIVE, “the expectations to biotech and AI are enormous. It is however essential the this potential is demonstrated in a reliable fashion” (KORA, Højgaard, & Kjellberg, 2017, p. 53). While VIVI’s notions are seconded by scholars, industry leaders and others, it is important to remember that “*there is a common trend to under estimate the time to implementation for megatrends, and undervalue the value in the long term*” (KORA et al., 2017, p. 53), and this is likely to apply to Smart Health Technology.

“Wearable devices such as smart watches are still pretty immature

still. I think that when they become less annoying to wear we will be integrating those data points in our healthcare system” (Moll, 2018).

As such the present state of Smart Health Technology is characterised by an enormous promise of future abilities, but for now the examples are few and while we are seeing mostly smartphone apps and some stand-alone products, the overall amount of truly Smart Health Technology is limited. In this argument, the pervasiveness of Smart Health Technology is not in debate but the current solutions’ abilities to analyse and provide actionable advice to users based on their health-data is limited, and as such the true potential in Smart Health Technology is in its future application.

“The state of Smart Health Technology is experimentation and only advanced users are really using it. For now it is very unreliable and sometimes do not work. In essence you cannot trust the data coming out of Smart Health Technology today. Once this gets fixed and we have done some clinical trials to show that one kind of wearable device actually delivers trustworthy data I think this will be integrated into our electronic health records and become part of the decision support that clinicians draw diagnostic information from” (Moll, 2018).

Industry leaders are arguing that we are at the very verge of achieving a good part of these promises and see a near future, before 2025, in which doctors apply Data Analytics in the diagnosis-stage of treatment within hospitals.

“Healthcare professionals use clinical decision support (CDS) systems to proactively react to indications for a given diagnosis and actively search for further information to qualify the diagnosis in question in order to ensure that best practice recommendations are taken into account for treatment. In a number of cases, patients will soon be able to carry out diagnostics using CDS, and receive advice and guidance regarding treatment” (Lerche, 2017).

2025

THE BIG CHALLENGE

While most of our interviewed experts agree that the field of especially wearable Smart Health Technology will increase and become pervasive in the near future, there is also consensus that making claims about what specific technologies will be worth focussing on is speculative, and that the best practice is to adhere to industry standards. This will likely lead to new technologies emerging for certain types of purposes or needs. Comparing the rapid development and adaptation of the smartphones, it is likely

that we will see a rapid deployment of a singular good idea either coming from the domain of health or introduced into healthcare from other fields. While this convergence of ideas and applications is nothing new, the sensor technology which is being perfected in the possibly near future will enable precision technologies to be applied as wearable devices with internet connection in the domain of healthcare, and thus offer a degree of monitoring and treatment which are unprecedented. This change will likely be slow and require several steps of research and development as well as making sure that the devices which are in use is able to perform with adequate precision so as to ensure their use.

“If we start offering advice to people, especially about their medical and health status, we need to really focus on the reliability and dependability of the sensors providing the data. There is a real challenge in making sure that those sensors are Working, calibrated and accurate and that’s actually a whole other dataset that needs to be accounted for” (Dean, 2018).

THE BIG PICTURE

According to Industry Analyst at Frost & Sullivan, Arjunvasan Ambigapathy, there is a growing market for Smart Health Technology which overall is under development. As these developments become fully developed, and as their effects merge, there will be significant change to how health is structured and delivered. In the below overview, selected technological innovations have been presented and arranged with respect to their estimated years of development indicated with red bars.

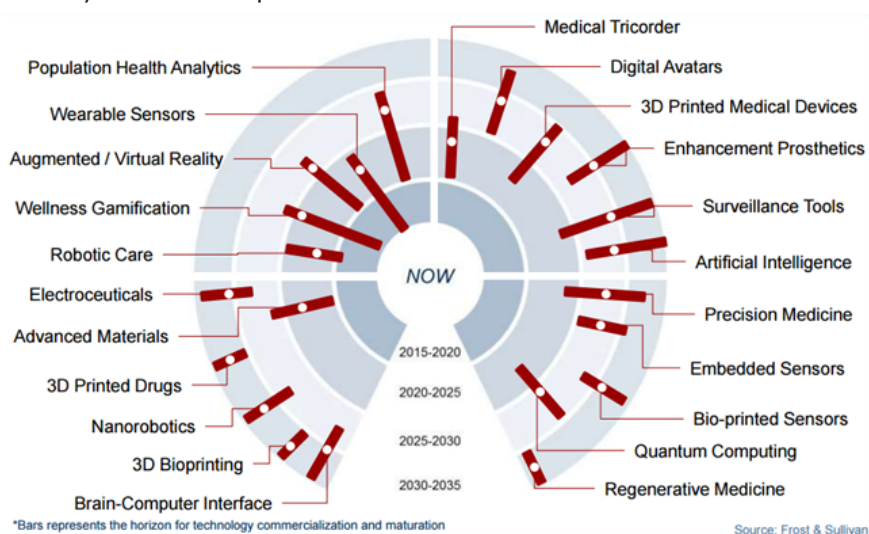


Figure 1: Frost and Sullivan overview of technology commercialization and maturation. (Lombardi, 2017)

DEMOGRAPHIC CHANGES WILL DRIVE DEVELOPMENT

While the nature of the technological developments for now remains a mystery, there is some consensus that especially the demographic change will make certain types of solutions more in need than others.

“At the top priorities I would say metabolic disease, cardio vascular disease and probably with an ageing population mental diseases such as dementia” (Dean, 2018).

SYSTEM CHANGE

It's clear that the introduction of Smart Health Technology will foster a change in the system which requires not only that we adopt a new way for managing citizens with diseases and special needs, but also a new way and more agile way for healthcare personnel to work with technological devices. While the use of technological devices in the Danish healthcare system is vast, the advances in especially Smart Health Technology will speed up the process of using telemedicine to remotely monitor as well as treat patients.

“I think a lot of things will happen in five years. And a lot of new expectations in the next generations will show up and we have to educate the people, our employees, much more in thinking different. Make a cultural change.” (Jest, 2018).

VALUES AND RISKS OF SMART HEALTH TECHNOLOGY

Smart Health Technology is said to have the potential to “...shape the life of the consumers and record, store and seamlessly share health information with users and care-providers which will have comprehensive and actionable information ready at hand” (Deloitte, 2016b, p. 12). This section will examine this claim in further detail and outline both the potential value and risk in the application of Smart Health Technology in the future, from four different perspectives: Citizens, Healthcare personnel, The Healthcare Sector and Society as a whole.

“There is much potential but there are just as many if not three fold more pitfalls” (Moll, 2018).

CITIZENS

Both the value and risk to Citizens from Smart Health Technology is significant. Without engaging in specific technologies, the overall value of Smart Health Technology is that of continuous monitoring of personal health and well-being as well as the integration and analysis of data collected from several sources.

“The global technological development has already revolutionised the health-sector in many ways. In the digital world, everything is within reach and citizens expect answers promptly” (Copenhagen Institute of Future Studies, 2017, p. 2).

VALUES

EARLY DETECTION AND PREVENTION

Central to the value of Smart Health Technology is the continuous monitoring of the health and well-being of citizens. At the very least, this enables users with information on their current health and notice to seek medical consultation or emergency attention. It is likely that we will see an overall increase in timely treatment as the time between detection of symptoms and treatments are administered is shortened. For chronic illnesses it is possible that treatment can be administered automatically on the go.

“By 2025, healthcare will be considerably more tailored to the individual profile of patients, the majority of who will meet their doctors informed and empowered by online sources and apps. Increased health literacy, and a growing spectrum of technology assisting in personalization of healthcare will enable earlier intervention and health coaching” (DNV GL, 2017, p. 9).

In these cases, it is vital that Patient obtained Data, or POD, is easily integrated into the official health records of the patient or at the very least that the official healthcare system is altered appropriately to an imminent threat to a citizen's life or wellbeing. In the case of e.g. diabetics it is clear that a reliable device which accurately could measure and analyse insulin-levels as well as administer a remedy for a variety of situations would make adherence to a prescribed treatment in adolescents higher. This would add value to both their immediate medical state as well as provide them with, and their parents, with peace of mind in knowing that that aspect of the condition is managed reliably.

"I think the great potential going forward for Smart Health Technology is that we can get continuous data points from our body and that is quite hard today. The normal healthcare regime is that you have a blood test drawn maybe one every half a year or maybe a little bit more often if you are chronically ill. Having continuous data about how your body is doing will deliver great advances" (Moll, 2018).

PHARMACOGENOMICS & PERSONALISATION

Smart Health Technology of 2025 will enable treatment based on the lives of citizens in combination with information taken from their genome. This will enable matching of specific genome mutations with drugs and treatment which have a proven positive effect or minimal side-effects instead of the current use in which medicine is administered with little or no regard to the genome of the recipient.

"One of the most important areas will be precision medicine of pharmacogenomics. I think it is really important to look into the combination of health data that we gather right now and then the coupling to our genome scanning projects because we know that this has a great influence on the way that drugs are absorbed and processes. For instance we know that some people who carry specific mutations will only experience the negative side effects of a drug and none of the intended positive effects. In the future we will see decision support systems which will tell us of any mutations carried by the patient which prescribing doctors need to take into account when prescribing medicines" (Moll, 2018).

RISKS

OPPOSITION TO CONTINUOUS MONITORING AND EFFECTS OF INSTANT

While the Smart Health Technology systems are not in deployment yet, the notions of instant access from other areas of modern life such as Smart-TV's are beginning to show in the Healthcare Sector. This has already been identified by researchers who have uncovered a growing tendency in the European population to question the current methods by the Healthcare System if they are not offered what they consider timely treatment or attention. In addition, it is highly likely that there will be a section of the population which will not adopt or accept continuous monitoring, and unless the Healthcare system integrates a way to provide care for this group there are at risk of receiving substandard care.

“The wrong thing to do is to ban the technologies from those who can afford it. The right thing to do is to find effective ways for everybody to access it. But just because you have access to it, does not mean that you will use it. We probably have to address this long term health issue in the education system far earlier than we do now, and with far more rigor than we do now” (Dean, 2018).

“[Why should citizens be] losing valuable time getting to a doctor or waiting for a visit at a time when there are technologies available to enable remote medical consultations.” (Liveri, Sarri, Skouloudi, European Union, & European Network and Information Security Agency, 2015, p. 17)

SAFETY AND SECURITY

As the continuous treatment of citizens health provides valuable information to the Healthcare Sector, this information is also valuable to other parties, and thus at risk of being accessed by unauthorised persons. In addition to this, there is a prevalent argument in the Nordic setting of universal government funded healthcare that this data can be said to be of value to private parties such as insurance companies. This issue is further strengthened in countries such as the US where medical treatment by a wide margin is provided by insurance companies.

“We could easily end up in a scenario where we are looking at surveillance technology instead of Smart Health technology. How do we prevent that what we now consider a Smart Health Technology and a great potential for the future will not become surveillance technology? How do we prevent that our ability to get information about our health is not misused by corporations or insurance companies?” (Moll, 2018).

HEALTHCARE PERSONNEL

While the overall aspect of the changes of the Healthcare system is described in detail the section on Integrated Health and Prehabilitation, the need for changed roles is accelerated by both by changes in demographics as well by the available Smart Health Technology and other forms of technology. With these advances it is commonly speculated that the roles of nearly all healthcare professionals will have to be reevaluated in the near future, due to the systemic changes in the Healthcare sector (KORA et al., 2017, p. 48).

“These technologies can empower medical practitioners. Within primary care to address a much higher proportion of their patient health care needs. It can allow them to maintain an ongoing caring relationship with their patient. It could ultimate enable the local medical practitioner to be the Orchestrator of a range of healthcare services of their patient. It also allows them to play a much stronger role on the preventative medicine for their patient” (McDonagh, 2017, 32:18).

“Right now we talk about the pre-hospital and I think that this will become much more important in the future and this will be a sub-part of the hospital were specialized nurses, lab technicians and clinicians in general will be looking at early signs and symptoms of worsening in general. I think this is one of the structural changes that we will see in the healthcare system” (Moll, 2018, 33:32).

VALUES

JOB SATISFACTION AND HEALTHCARE SECTOR TRANSPARENCY

With the implementation of Smart Health Technology, the healthcare staff will be able to receive much of the recurring monitoring of patients remotely, and as such will be able to monitor them from afar. In the relatively few cases of hospital admissions, the need for direct supervision will be lowered due to advanced monitoring and in the majority of follow-up consultations from out-patient treatment, the data will be recorded, analysed and presented automatically with minimal human intervention. Instead healthcare staff will focus on motivation, guidance and assistance.

PHARMACOGENOMICS & PERSONALISATION

With the use of Pharmacogenomics and high-quality home monitoring systems, healthcare personnel will have access to not only a real time updated and readily accessible record of their patient’s health and well-being, but also access to patient-tailored treatment based on personal health data. This will change the nature of interaction toward prevention and helping citizens understand their health data and consequences of actions, as well as providing assistance and motivation to changing behaviour.

“Portable devices such as smartphones, portable multi- life parameter monitoring equipment (wearables, health trackers) or electronic health records will cause a rapid increase in the volume of data used in clinical practice. When EHR s (Electronic Health Records) will be filled with complete medical history, there will be an opportunity to document people’s activities, nutrition, lifestyles, as well as elements of mental health that are still beyond our control. A detailed picture of life will help in setting up optimal models of prophylaxis and those very models will have a decisive role in healthcare, pushing intervention medicine into the background” (eHealth 2016, 2016, p. 30).

RISKS

CONTINUOUS MONITORING AND INSTANT ACCESS

With patients and citizens monitoring themselves and being in control of the data being recorded it is likely that some users will engage and analyse their data independently. As the Smart Health Technology develops into more reliable systems and the abilities of Data Analytics and advanced, users will either be informed of serious diagnosis by an automated system or be withheld from that type of data until medical staff can analyse and inform the citizen. In addition, there will likely be a growing desire from patients to be able to seek medical consultations at all times.

“The danger is [...] that citizens and health consumers might not seek the advice of a qualified medical practitioner, in some case because a smart technology had negated the need to do so, and that isn’t a desired outcome. So there is an ethical need for smart health providers to not overpromise, what technology can do, and further there is a need for regulation to back this up, to ensure that the marketing and the positioning of these technologies and these devices does not overpromise, does not mislead the consumer” (McDonagh, 2017).

CONTINUOUS MONITORING AND INSTANT ACCESS

With the development of increasingly more personalised treatments, the jobs of the Healthcare staff will change. This change is compounded by the overall change in the Healthcare system to adapt to prevention rather than reaction, and will require Healthcare staff to train in the operation of different types of Telemedicine, as well as other forms of Smart Health Technology.

BARRIERS FOR COMPANIES

There are, however, also some barriers for prehabilitation solutions to overcome:

RESEARCH AND DOCUMENTATION IS SCARCE

As the prehabilitation field is not as consolidated and documented yet, the scarcity of research and documentation may lead to resistance for immediate sale of prehabilitation solutions. Research and documentation will probably be necessary before a sale can be realised. Josep Roca explains that:

“the problem is that both the financial and cultural drivers are very strong, but we in the school of medicine teach traditional medicine. So, the inertia, meaning the time between the design of a new healthcare system, a new way to approach disease and to do the research and practice, is too long. It takes too much time” (Roca, 2017).

CROSS-SECTOR COMPLEXITY

As with rehabilitation, prehabilitation interventions will have a cross-sectorial nature, in that the actual procedures, such as major surgery, are carried out by the hospitals, whereas the prehabilitation interventions are done in the homes of the citizens, and as such concern primary care. As described in Integrated Healthcare Services, the coordination between hospitals and primary care can be a challenging field. Companies would therefore benefit from understanding the complexity of stakeholders, systems, financial structures and processes. Significant disadvantages or changes for one stakeholder may necessitate a political or management decision across sectors.

CONSIDERATIONS FOR COMPANIES

When developing solutions for healthcare, particularly solutions that handle personal data, the following aspects will be relevant to consider.

GENERAL DATA PROTECTION REGULATION (GDPR)

In May 2018 the General Data Protection Directive from EU (GDPR) will enter into force in the EU (European Council, 2016). The purpose of the directive is to strengthen citizens' fundamental rights when it comes to data, privacy and digitalisation – but also to simplify rules for companies and thereby facilitate growth. Some of the more noteworthy changes enforced by the directive are the possibilities of issuing fines amounting to up to 4% of a company's annual turnover.

In order to adhere to the GDPR, companies may look at the Guidelines for Cybersecurity (ISO 27032).

CONSENT

The regulation regarding data subject consent has been further strengthened and clarified. Consent must be explicit and the citizen must be clearly informed of the precise and defined purpose of data collection. Furthermore the citizen has the right to revoke consent. If consent is revoked the data must be deleted and proof that it has taken place presented to the citizen. This will affect all companies handling data pertaining to the citizen's health.

DATA PORTABILITY

Data portability is a new topic introduced by the GDPR. With GDPR the citizen will have the right to data portability. This means that if you collect personal data the citizen has the right to receive the personal data concerning him or her in a structured, commonly used and machine-readable format. They also have the right to transmit those data to another organisation that collects data about the citizen. The purpose of this obligation is to limit the number of times citizens have to answer questions about the same subject matter, e.g. age, height, gender etc.

This is particularly interesting from a healthcare perspective because data might be required to be shared across different organisations in the healthcare sector to a much greater extent than they are today. This might also prove a new business opportunity for companies, since there may be a whole new market emerging for solutions to support data portability, e.g. by providing system integration or sharing information between different IT systems.

EUROPEAN MEDICAL DEVICES DIRECTIVES

In addition to the more general GDPR directive, an updated directive on Medical Devices will enter into force in the spring of 2020 and 2022. The two directives (EU) 2017/745 “MDR” & EU 2017/746 “IVDR” - (European Parliament & European Council, 2017a, 2017b) heavily regulate what is defined as medical devices, and how such devices can be tested and used within the boundaries of the EU. This is central for especially Data Analytics and Smart Health Technologies. ‘Medical purpose’ is defined as any type of diagnosis, prevention, monitoring or treatment or alleviation of disease or disability. The vast majority of devices which collect health information are likely to be considered medical devices, even if they do not process or analyse the data. Companies operating within the domain of health should proactively investigate compliance with these regulations and adjust development processes accordingly.

ETHICAL GUIDELINES

Bringing technology into the sphere of healthcare services brings with it relevant ethical considerations. The Health Innovation Centre of Southern Denmark has developed two videos that illustrate the expectations and challenges that may arise when new technology meets the healthcare sector. The videos focus on the perspectives of the patients at home and the clinicians working across sectors, respectively. Companies may consider these ethical aspects in their development process.

ADVICE FOR COMPANIES

Companies developing solutions for prehabilitation in the Danish healthcare sector of 2025 should particularly consider the following:

UNDERSTAND STAKEHOLDERS AND INCENTIVES ACROSS SECTORS

As with rehabilitation, prehabilitation interventions will have a cross-sectorial nature, in that the actual procedures, such as major surgery, are carried out by the hospitals, whereas the prehabilitation interventions are done in the homes of the citizens, and as such concern primary care. As described in Integrated Healthcare Services, the coordination between hospitals and primary care can be a challenging field. Companies would therefore benefit from understanding the complexity of stakeholders, and the pros and cons that their solution will present for each stakeholder. Significant disadvantages or changes for one stakeholder may necessitate a political or management decision across sectors.

As Hanne Tønnesen puts it:

“Money and business cases can convince managers and insurance companies etc. to do this implementation, especially if they see the money flow themselves. If you see it go to another box then you might not have the same interest” (Hanne Tønnesen, 2018).

Selling solutions to the public sector can be a lengthy and complex process due to the stakeholder complexity and procurement processes. In this connection Helle Aarøe Nissen underlines the importance of the promotion of a solution and explains that:

“some firms get to know how the system actually works and they get to know that in the healthcare system there are lot of different actors who influence the decision to buy a new innovative solution. So some of the firms who succeed to commercialise solutions across hospitals and regions, they actually take into account that there are a lot of different stakeholders at different levels within the healthcare system, and they use that when they promote their innovative solutions. So that they remember to take into account the different needs and the different values which different actors want to have taken into account” (Nissen, 2017).

DESIGN THE FULL SOLUTION

Adapting new prehabilitation programs may fundamentally change the related workflows and service delivery across sectors. It is essential that companies understand the impact that their solution has on workflows, patient pathways etc. Hal Wolf argues that:

“Technology overall is never the answer! In any situation. In any industry. In any moment in time. You know, technology is a component of a full answer” (Wolf, 2018).

One strategy for ensuring that a solution can be integrated in the daily operations could be to collaborate with the public customer in designing new context-specific workflows across sectors. According to Christian Bason, CEO of Danish Design Center, companies can use service design as a force of change from a product- to service oriented business strategy in order to survive in a highly competitive market that demands user satisfaction. In order to succeed companies must challenge their assumptions regarding their company and solution and take their point of departure in the user perspective as a motivating force for change. When taking this strategic approach companies can drive digital transformation through new products and services (Bason, 2017). Chesbrough explains how companies in any industry can make the shift from product- to service-centric thinking, from closed to open innovation where co-creating with users enables sustainable business models that drive continuous value creation for users. He also pinpoints that an open service innovation approach must be applied because the healthcare system is a highly connected economy (Chesbrough, 2011).

Service design is active planning and organisation of people, infrastructure, communications, media and services. Service design therefore contributes to good coherent service experiences. Service design helps to read, understand and identify users’ needs, expectations, and dreams, so you have a solid foundation for developing new workflows, services and products that actually work. Service design puts the user at the center, whether they be staff, patients or relatives. It is absolutely essential that those who use the solution should also help define it. User involvement ensures that you solve the real issues. Not only what the supposed problem or need is. Service design gives you a fresh look into your own organization. It’s a set of fresh eyes that challenges your habits and what you usually do, which has become a part of everyday life and seems almost invisible to you (Schneider & Stickdorn).

Hal Wolf underlines that integration of technology into the daily operations is imperative:

“So if we ever continue to hang our expectations on some silver bullet that is created by technology, it just doesn’t work that way. It is how you integrate the technology into actual functional care and daily usage (...) There are thousands of technologies available, they mean nothing until you load them into your own domain and begin to use them as a part of how you deliver care” (Wolf, 2018).

INVEST IN THE LONG TERM

Prehabilitation is still a fairly new field, which is not adopted consistently and systematically in healthcare yet, neither internationally nor in Denmark. Companies should therefore expect the development and sale of prehabilitation solutions to involve a longterm strategy and a research foundation. The longterm strategy would benefit from project collaborations, in which the technology is matured and documented through continuous user involvement.

WORK WITH MOTIVATIONAL ELEMENTS

Prehabilitation is dependent on the motivation and active participation of the citizens/patients. Solutions that include (personal) mentoring or coaching based on monitoring and presenting progress and activity, either as embedded functions in the solutions or integrated with healthcare personnel, who use the solution to monitor and communicate with the citizen/patient in a coach-like role, may be more likely to encourage behavioural change and achieve results. Developing solutions that are attractive enough for the citizens to want to use them saves the healthcare sector the efforts of convincing, encouraging, or potentially even forcing, people to use them. For patients/citizens to take an active role in their care experience and choose their own care alternatives, companies could build in motivational aspect.

Hanne Tønnesen argues:

“It is a natural thing to include all the new developments into prehabilitation. I mean if you develop some new tools that can make it easier, make it fun to exercise, if you make some digital tools to support changing lifestyle life habits ... And every time you develop new treatments, new interventions, new ways of living, we should absolutely think about how does this affect my health in general and does this effect our patients, can we use this, and I think the intelligent digital solutions are huge way forward” (Hanne Tønnesen, 2018).

Motivational Elements, such as individualised/personalised solutions, continuum of care perspectives, flexibility, instant gratification etc. are relevant to consider, when companies aim to make solutions attractive enough to motivate users to participate actively in their own health. Gamification and game theory, amongst others, can help to conceptualise potential solutions, as these methods have the ability to activate patients and make them accountable for their health choices (Deloitte, 2016). Peder Jest agrees: *“what we see in the play and the game industry are also possible to use in the healthcare sector” (Jest, 2018).*

EMPOWER PEOPLE, TO COUNTERACT POLARISATION

Not all citizens will have the same capabilities to engage in prehabilitation interventions, which could affect equality in healthcare. Developers of prehabilitation solutions should consider how and to what extent their solution can support those who do not have the capabilities themselves.

GENERAL ADVICE

In their prioritisation of future research and development activities, companies that develop solutions for the Danish healthcare sector of 2025 are advised to consider how to:

- Solve the User's Needs
- Co-Create with Users and Stakeholders
- Understand and Document the Value of their Solutions
- Contribute to Implementation

SOLVE THE USERS' NEEDS

"It is not technology for the technology's sake; it is for the patient's sake we are working!" (Jest, 2018).

Peder Jest underlines that serving the patients is the primary purpose for the healthcare system. The development of new solutions should be centered around the users and their needs.

UNDERSTAND THE NEEDS AND CHALLENGES OF THE USERS

The users are the experts! A common challenge for development of successful solutions is lack of knowledge about the users. Investing the time and resources in identifying and understanding the needs and challenges of the future users of your solutions may be a worthwhile investment.

Erik Jylling says:

"Just bringing in new solutions and declaring that innovation will do it is not enough for a public healthcare system. Who is against innovation? Nobody! But we need to have solutions that can help us running the system. And we have to have the ability to assess that the solutions are also in favour of being integrated in the system. So it should benefit the patient, the outcome, and it should also benefit the spendings of the public economy" (Jylling, 2017).

The healthcare sector is interested in solutions that match their needs and challenges.

Hal Wolf underlines:

“Companies have got to figure out how to help integrate and develop innovations that are not just interesting, that can be utilised by the health systems themselves. And that is the big challenge that companies have, it is not about simply developing (...) technology. Companies that are developing technology for technology’s sake will not win!” (Wolf, 2018).

For companies it may be relevant to look into the fields of user-centred design and -innovation, anthropology and design. These fields may offer approaches and essential tools to uncovering unrecognised needs and transforming these insights into valuable solutions.

DESIGN FOR USABILITY

The technological development offers many opportunities for new solutions, and there is undoubtedly a vast national and international market for healthcare solutions (Jylling, 2017), however it is essential that companies and developers focus their efforts on developing solutions that address and solve the actual needs and challenges of the healthcare sector and their daily operations.

Hal Wolf goes as far as to say:

“Technology by itself without the process piece and the people piece that sits behind it, it’s useless, it means nothing” (Wolf, 2018).

When designing new technologies it will be important to accommodate the users and design for user preferences and capabilities. John Christiansen argues that:

“for new technologies, in the future I (nurse) will not need to educate myself for new technologies but technologies will be ready to incorporate us all, whoever I am, without needing to read piles of manuals but that it will be more intuitive” (Christiansen, 2017).

He continues:

“if systems are so complicated that we have to educate ourselves to understand the systems that we use for reporting, then maybe we are not the ones who need to be educated, maybe it is the way we think systems that is not intuitive enough” (Christiansen, 2017).

In other words, technologies should be adjusted to fit the capabilities of the users and not the other way around.

CO-CREATE WITH USERS AND STAKEHOLDERS

POOL MULTIDISCIPLINARY RESOURCES IN OPEN INNOVATION COLLABORATIONS

There is a general trend towards open innovation, in the acknowledgement that the benefits of pooling resources and knowledge allow 1 plus 1 to equal 3.

Peter Watts argues the importance of a multidisciplinary approach. He argues that companies:

“need to get a balance of skills (...) My team is made up of technical people, medical people, financial, legal, and I think that healthcare is so complicated, it needs understanding, it needs empathy, it needs lots of different skillsets. (...) I've been in technology all of my life, and I've been very lucky to see many good things happening in that time. And I'm very aware that technology isn't the solution to anything, it's the use of it that's the value. And you need smart people to do that, and you need multi-discipline people” (Watts, 2017).

Carsten Obel agrees that multidisciplinary collaboration is a good strategy:

“You should work together with people who have quite as different backgrounds as possible and engage in as many collaborative networks as possible, but still have the focus on the citizen and the value creation in focus” (Obel, 2017).

A company should not be an island in itself but acknowledge that others may have knowledge and expertise that is worth utilising to accelerate and improve development of new innovation. Especially large corporations could benefit from collaborating with SMEs/ smaller companies to a greater extent, by e.g. auctioning their needs for small companies to develop on (Munksgaard, Johnson, & Patterson, 2015). This is both the fastest process as well as the most cost-effective in the long run. Both large and smaller companies can utilise their best skills, which are e.g. the enthusiasm and ideating skills of small, entrepreneurial companies and the grounded strategy and long experience of larger corporations, which also often have more conservative professions and less resources for experimentation and new thinking (Nissen, 2017).

Peter Watts agrees that large companies and smaller companies could benefit from collaborating:

"Big companies can explain their roadmap and where they are going and what they need, and the benefit to the industry is fantastic. They may have big money for R&D but they don't always have the time and they don't always have the enthusiasm that small companies have. So bringing those together I think, is a real big key, and I think the role of government is really important too" (Watts, 2017).

Mature Solutions through Public-Private Collaboration

There is a growing general interest from public partners in Scandinavia in opening up and collaborating with private partners in Public-Private Partnerships (PPPs), Public-Private Innovation Partnerships (PPIs) etc. This openness enables companies to get access to and collaborate with the public healthcare sector (Nissen, 2017). Collaboration with public partners presents a significant opportunity for private companies. However, it is important that companies are aware that the healthcare system is a 'supertanker'. Things take time; e.g. rules and regulations, particularly within public procurement, are time-consuming. Quick wins are not possible and companies should expect a long lead time from the first dialogue to a contract (Øllgaard, Riis, Boding-Jensen, & Garsdal, 2016). This timespan may clash with the short-term focus of many companies, particularly SMEs. Companies are advised to invest in the long term when collaborating with public partners.

The Capital Region of Denmark argues that bidding on a tender does not start with writing the bid. They advise companies to: "Communicate with the municipalities leading up to a tender and influence the process. Prioritise which tenders you want to invest in" (Øllgaard et al., 2016). The primary focus and outcome of public-private collaborations is not sales/procurement. Helle Nissen argues that from a company perspective collaborations are a long-term strategy to achieve a) insights into needs and organisational structures, b) further needs-based development of a solution, and c) networks with relevant stakeholders (Nissen, 2017), all of which can influence future sales potential for a solution.

FAIL AND LEARN EARLY THROUGH USER TESTING

Fail fast, succeed sooner! A prototype is not a tool to prove that you are right. It is a tool to help you learn. User testing is an essential part of innovation processes within healthcare. Getting new insights and knowledge about stakeholders through testing and co-creation can ensure that a solution meets the user needs and demands.

The general rule of thumb is to test early, fail fast and learn cheaply. Helle Nissen recommends that companies: "test it! Have different kind of user groups to test it. Not only focus on one user group, but have different kind of stakeholders test the solution. And have a dialogue also with different kinds of stakeholders to understand what they value, and then you can adapt the solution so that it fits these kinds of values among the different stakeholders" (Nissen, 2017).

Carsten Obel argues that the possibilities of testing is special and very valuable for Denmark:

"Testing approves that it actually works and gives an 'approved in Denmark' sign. So I think this is a great opportunity that health providers have in Denmark, because this doesn't exist in any other place in the world, except for the Nordic Countries" (Obel, 2017).

John Christiansen believes that there are so many needs in the healthcare system that new solutions can address, however companies need to prepare to fail and learn, and they need to investigate the market:

"The challenges will be having the energy and courage to fail many times and having an overview of whether what one is developing is already out there" (Christiansen, 2017).

SAVE TIME THROUGH ESTABLISHED CHANNELS

Each public region in Denmark has established a 'single-point-of-entry' for the industry (En indgang), similar to the single-point-of-entry for organising collaboration between public and private partners that many municipalities have. These access-points are specialised in public-private collaboration and matchmaking. They have insights into which departments and health professionals may be interested in collaborating within a specific field as well as access to test facilities and clinical trials, saving companies the time-consuming task of knocking on multiple doors.

UNDERSTAND AND DOCUMENT THE VALUE OF SOLUTIONS

"Some firms get to know how the system actually works and they get to know that in the healthcare system there are lot of different actors who influence the decision to buy a new innovative solution. So some of the firms who succeed to commercialise solutions across hospitals and regions, they actually take into account that there are a lot of different stakeholders at different levels within the healthcare system, and they use that when they promote their innovative solutions. So that they remember to take into account the different needs and the different values which different actors want to have taken into account" (Nissen, 2017).

Selling solutions to the public sector can be a lengthy and complex process

due to the stakeholder complexity and procurement processes. It is important to understand the value of a solution for the relevant stakeholders, and to document this value.

Ensure Business Model Agility and Adapt to Diverse Contexts

It is important to be aware of the direction that incentive- and payment structures are moving in Denmark and how it will affect your solution. Company business models should contain the flexibility and agility to incorporate this development. This agility is even more necessary for companies aiming to bring their solutions to international markets where the financial structures are considerably different.

Erik Jylling argues the relevance of ensuring scalability of your solution:

“They have to take into account that the product should be scalable, and the product should bring us not only new products but it should bring us solutions that helps us solve the big fundamental structural problems that we see in the healthcare system, not only in Denmark but internationally, today and especially in the years to come” (Jylling, 2017).

As previously described in Fail and Learn Early through User Testing there are many opportunities for testing solutions in a Danish context. It is, however, important to be aware that testing a solution in e.g. one hospital department with a few healthcare personnel representatives is unlikely to cover the organisational diversity across all Danish hospitals. Even less so across international hospitals.

Companies should develop solutions that incorporate appropriate flexibility to accommodate the diversity of organisational needs, nationally as well as internationally. According to Helle Nissen some “firms as a strategy choose to engage in new collaborations (Public-private partnerships) in order to improve their product or in order to adapt it to a specific context” (Nissen, 2017). She argues that:

“firms have to interact with these different actors in some sort of way in order to adapt the development of their solutions, so they fit with the different kinds of users in the healthcare system” (Nissen, 2017).

Prove and Document the Value

Helle Nissen underlines the importance of understanding your stakeholders and procurement processes (Nissen, 2017). Healthcare budgets are under increasing pressure and the healthcare sector is interested in the proven value and effect of solutions.

Erik Jylling argues that: “companies that are concerned about developing new solutions for the Danish healthcare system should take into account that the economical pressure for public economy now and in the years to come will be quite substantial” (Erik Jylling, 2017).

He underlines that the healthcare sector “have to have the ability to assess that the solutions are also in favour of being integrated in the system. So it should benefit the patient, the outcome, and it should also benefit the spendings of the public economy“ (Jylling, 2017).

This necessitates not only an understanding of the value of the solution but also evidence of this value.

Business cases and technology assessments are often required prior to a sale to a public partner. Business case processes can be both time- and resource consuming. Therefore it is relevant to consider to what extent the results, criteria, quality and validity of business case results are transferable to other settings and customers. Companies should take into account that a public partner will usually have a primary interest in business case results for their own specific context, so it will, as a general rule, be the responsibility of the company to ensure the focus on transferability of results.

UTILISE POLITICAL DIRECTIONS AND FUNDING OPPORTUNITIES

The Danish healthcare sector is mainly governed by politicians. Continuously assessing and following the political and public opinion, which is dynamic, may enable companies to utilise e.g. political waves to strategically time initiatives and communication in favour of the solution. It is also relevant to keep an eye on and utilise the many funding possibilities for innovation.

CONTRIBUTE TO IMPLEMENTATION

It is crucial to be aware of the importance of implementing solutions. Peder Jest underlines:

“You can invent anything and you can find evidence for everything but if you cannot implement it, it doesn't matter” (Jest, 2018).

Like many others, Hal Wolf argues that implementation is much harder than the actual technology development:

“Well, I think the implementation of any technology at the hospital level, moving into the next generation of healthcare, just like in any industry, always comes down to three basic things; it's people it's process and it's technology! (...) the technology inevitably is the easiest part. It is changing the processes necessary to take care, or

utilise the technologies, and then the cultural components of how to integrate them into daily work habits, and our expectations.”

Solutions that support the healthcare sector and contribute to implementation may have an advantage.

Support and Co-Create Implementation Processes

Jørgen Løkkegaard, CEO, The Danish Technological institute and Innovation Manager in Patient@home states in Mandagmorgen:

“Our experience is that technology represents only 20 % of the task with successful implementation, while the culture of technology accounts for 80 %” (‘Jørgen Løkkegaard i Mandag Morgen nr. 35, 9.10.2017’).

It is a common challenge in the public sector that some new solutions, which have been procured to save time and increase quality, are not fully implemented or adopted. This affects both the public sector, who do not fully realise the intended benefits of the solution, and the company, for whom the case becomes a poor reference.

It is clear that implementation is important and difficult (Wolf, 2018). Companies that are able and willing to support the public sector and co-create a strong implementation process for their solution are more likely to achieve a mutually beneficial outcome for all stakeholders.

Design the Full Solution

“Technology overall is never the answer! In any situation. In any industry. In any moment in time. You know, technology is a component of a full answer” (Wolf, 2018).

Hal Wolf makes it crystal clear that technology is just one part of the puzzle; a much bigger part of that puzzle is the full service design. According to Hal Wolf the value of new solutions diminishes if the processes and culture are not changed (Wolf, 2018). According to Christian Bason, CEO at Danish Design Center, in order to succeed companies must challenge their assumptions regarding their company and solution and take their point of departure in the user perspective as a motivating force for change (Bason, 2017).

Service design is active planning and organisation of people, infrastructure, communications, media and services. Service design contributes to good coherent service experiences. It helps to read, understand and identify users’ needs and expectations so that you have a solid foundation for developing new workflows, services and products that actually work. Service design puts the user at the centre and gives you a fresh look into your own

organisation, its habits and challenges (Schneider & Stickdorn).

Designing the full solution is therefore about combining the technology and service components into an integrated solution, and Hal Wolf underlines that what matters is integration of a technology into the daily operations and workflows: “There are thousands of technologies available, they mean nothing until you load them into your own domain and begin to use them as a part of how you deliver care” (Wolf, 2018).

REFERENCES

Care-O-Bot. (2012).

Care-O-Bot 3 as a Test Platform and Inspiration. Retrieved 16 January 2018, from <http://www.en.patientathome.dk/projects/care-o-bot-3-as-a-test-platform-and-inspiration.aspx>

Copenhagen Institute of Future Studies. (2017, August).

Fremtiden for det danske sundhedssystem (2030). Retrieved 16 November 2017, from <http://iff.dk/fremtiden-for-det-danske-sundhedssystem-2030/>

Dean, K. (2018, January 4).

Kevin Dean.

Deloitte. (2016a).

Boosting patient empowerment and motivational pull (Mentions). Retrieved from <https://www2.deloitte.com/de/de/pages/strategy/articles/boosting-patient-empowerment-and-motivational-pull.html>

Deloitte. (2016b).

Healthcare and Life Sciences Predictions 2020. Retrieved from <https://www2.deloitte.com/uk/en/pages/life-sciences-and-healthcare/articles/healthcare-and-life-sciences-predictions-2020.html>

DNV GL. (2017).

Technology Outlook 2025. Retrieved from <https://to2025.dnvgl.com/>

eHealth 2016. (2016).

Polish Healthcare Journal.

Genomics England. (2018, January 8).

GenomicsEngland.co.uk. Retrieved 12 January 2018, from <https://www.genomicsengland.co.uk/the-100000-genomes-project-by-numbers/>

Jest, P. (2018, January 2).

Peder Jest.

Jylling, E. (2017, December 13).

Erik Jylling.

KORA, Højgaard, B., & Kjellberg, J. (2017).

Fem megatrends der udfordrer fremtidens sundhedsvæsen. KORA. Retrieved from <https://www.kora.dk/aktuelt/nyheder/2017/fem-megatrends-vil-forandre-fremtidens-sundhedsvaesen/>

Langkilde, N. J. (2018, January 3).

Niels Jørgen Langkilde.

Lerche, S. (2017, November 28).

Steffen Lerche.

Liveri, D., Sarri, A., Skouloudi, C., European Union, & European Network and Information Security Agency. (2015).

Security and resilience in eHealth security challenges and risks.

Heraklion: ENISA. Retrieved from <http://bookshop.europa.eu/uri?target=EUB:NOTICE:TP0415824:EN:HTML>

Lombardi, G. (2017, September 1).

How emerging technology is re-inventing the medical profession.

Retrieved 23 January 2018, from <http://www.marginalia.online/how-emerging-technology-is-re-inventing-the-medical-profession/>

McDonagh, N. (2017, November 28).

Niall McDonagh.

Moll, J. (2018, January 2).

Jonas Moll.

msftsverige. (2016).

Nordic Health Innovation – Virtual Care Rooms. Retrieved from <https://www.youtube.com/watch?v=MI2NM6MF9LE>

Sens Motion. (2012).

Efficient home rehabilitation tool SENS motion®. Retrieved 16 January 2018, from <http://www.en.patientathome.dk/projects/efficient-home-rehabilitation-tool-sens-motion%C2%AE.aspx>

Smart Silver Economy. (2018, January 11).

Retrieved 11 January 2018, from <http://www.smartsilvereconomy.eu/>

The Progeria Research Foundation. (2017).

Retrieved 15 January 2018, from <https://www.progeriaresearch.org/about-us/>

VR Rehab. (2012).

Using Virtual Reality for Brain Injury Rehabilitation. Retrieved 16 January 2018, from <http://www.en.patientathome.dk/projects/using-virtual-reality-for-brain-injury-rehabilitation.aspx>

Wolf, H. (2018, January 3).

Hal Wolf.