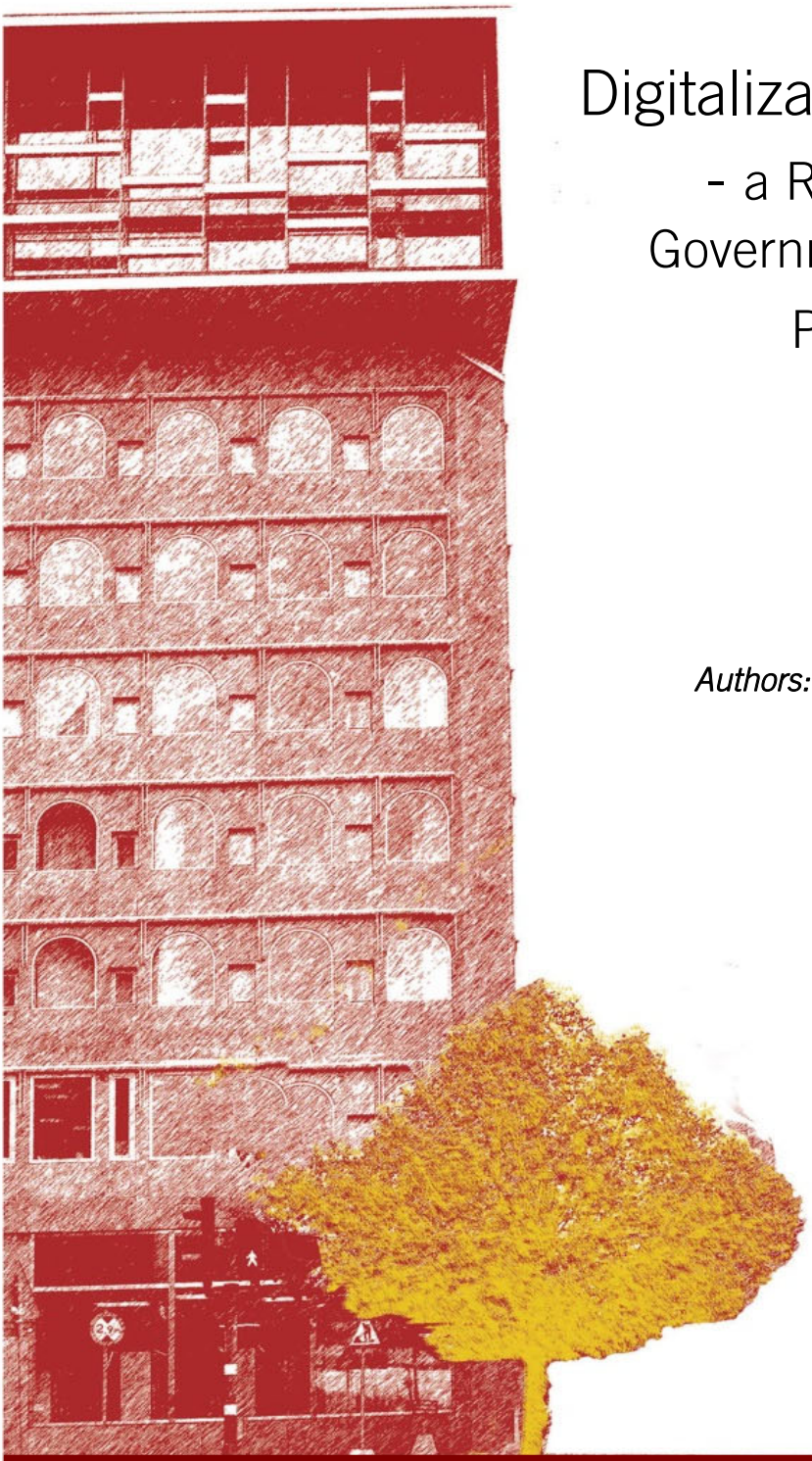

Digitalization and Health Care

- a Report to the Swedish Government's Expert Group on Public Economics

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The Expert Group on Public Economics

2018:6 English version

Preface to the English translation

The Expert Group on Public Economics (ESO) is an independent committee under the Swedish Ministry of Finance. ESO's main aim is to improve the knowledge base for future economic and fiscal policy decisions by assigning researchers and other experts to conduct studies that are published in ESO's publication series (ToR 2007:46).

This report is a translation of the ESO-report "*Operation digitalisering – en ESO-rapport om hälso- och sjukvården*", originally published in December 2018. In all its content, the translated report reflects the original version.

The authors' work has been conducted in dialogue with a reference group chaired by professor Sylvia Schwaag Serger, member of ESO's board of directors. The content of this, and all other ESO publications, are the sole responsibility of the author(s). They are also solely responsible for conclusions and recommendations in the report.

Content

Summary

Digitalization can open new pathways to health care, strengthen patients, and also improve the accessibility of care. Taking advantage of these possibilities will be crucial to addressing citizens' high expectations of health care and the growing needs of an aging population. Sweden is facing a strategic choice for the future of health care, where digitalization plays a vital role. New technology enables citizens to better monitor their health, take preventive measures, and, if necessary, take more control of their health situation. Technology can thus enable more and better quality care, despite fewer physical care visits.

In this report, we present the state of knowledge about the effects of digitalization on health care, based on a review of the research literature. We discuss how these effects can be interpreted in a Swedish context, and conclude that quality improvements can be achieved in almost all areas. In elderly care, technology can lead to improvements in mobility, social contact, and increased independence. The accessibility of Swedish health care has improved since 2016, when private telemedicine firms began offering video-calls via smartphone apps. Health care is mainly tax-financed, and so are the telemedicine services. These developments have resulted in increasing economic tensions between various actors, mainly due to the complex and outdated public sector remunerations systems. The benefits of video calls should be markedly high in rural areas, but so far it is mostly residents of major cities who use telemedicine.

Gains from digitalization are not automatic. Instead, they require active support, organization, and cooperation between, as well as within, different levels of government. The benefits of digitalization can be substantial, but when things go wrong, the risks to patients are significant. It is also the case that older people today often find

it harder to use digital services. The regions need to make sure that services are easy to use and that data is secure.

Overall, we found a significant disparity between Sweden's stated political vision – to become the best in the world on e-Health – and the problems reported by health care staff, such as incompatible IT systems, duplication, and unclear control. Providing better support to staff is crucial to meeting the health care needs of the future and achieving the positive transformation that digitalization can bring.

What should be done? In order to benefit from the potential of digitalization, legislators should deal with both legal and practical barriers. The challenges are well illustrated by the experience of the government's agency for e-Health and its difficulties in launching a platform for e-Health services. The platform was intended to offer various health care-related web services to Swedish citizens, but after several years of work, it seems likely to be discontinued.

What does this failed digitalization project mean for Sweden, a country with a sizeable geographical territory, but which is, in many regions, sparsely populated? A critical insight about digital platforms is that their impact fundamentally draws from economies of scale and network effects. Experience shows that platforms that attract large user flows expand and thrive when they are open to third-party developers who can create new services. Here data security and privacy are of crucial importance. Without proper safeguards, individuals may be at risk if data is exposed or comes into the wrong hands. But we believe personal security has been overemphasized, eclipsing the benefits of big data for the individual and society as a whole. Large amounts of data can help save lives and reduce suffering by facilitating the development of new knowledge, better diagnoses and more effective treatments. Sweden needs to continue to protect personal data, but also find a way forward that is more pragmatic, weighing more appropriately the benefits of using data to improve health care.

It is equally important that county councils improve their cooperation in areas where unnecessary bureaucracy creates obstacles to care by dividing regions and separating public and private sector health care providers. The public sector should put even more effort into creating a common technical infrastructure that is compatible across the country. This will provide better opportunities for entrepreneurs to create new, innovative services

without the risk of running into red tape as they cross into new regions. Continuing on the same path as today without substantial reform is unlikely to lead to a dramatic deterioration of health care services in the short term, but it will likely reduce or even negate future gains.

1 Introduction[1]

The digitalization of health care is part of a transformational shift affecting the economy and society. The transformation of health care should be seen in this broader context. Many of the changes come directly or indirectly through the labor market and the work-related skills that are in demand. For decades, the labor markets in the OECD countries have shifted towards increased polarization. Middle-level positions now comprise a smaller share of all jobs, while low- and high-skilled jobs have seen a corresponding increase.[2] The trend towards polarization started well before the advent of large digital firms and the large-scale digitalization we observe today. A range of industries and services are in the process of being transformed. In the past, phases of rapid technological change mainly affected the manufacturing industry, but digitalization affects the service sector as well, impacting a broad range of activities, from jobs in logistics to legal or financial services. In health care, software robots based on so-called neural networks are well on their way to making better and faster cancer diagnoses than dermatologists.[3] Progress has also been made with diagnoses of eye diseases using AI (artificial intelligence) and machine learning.[4]

New digital giants are influencing society on several fronts. They have established themselves in mature industries and offer improvements to existing services at a lower cost. Moreover, wholly new services are being provided that would not have been possible

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[2] Goos et al. (2014), Acemoglu and Autor (2011).

[3] Economist (2018), Haenssle et al. (2018), Esteva et al. (2017).

[4] De Fauw et al. (2018).

without vast networks and digital computing power. This change has meant that incumbent companies have been pushed aside or even replaced by digital startups. The label FAANGS (Facebook, Apple, Amazon, Netflix, and Google) has come to characterize the increasing dominance of these new digital companies, who have gained monopoly positions through the power of operating platforms that attract many users. Thanks to these platforms, FAANGS can easily offer new services to a large number of users. The power of the platform distinguishes digitalization from previous periods of structural change.

Health care is an area where both the scale of digitalization, and interest in potential applications, has increased notably in recent years. Every modern smartphone already has a variety of apps that people can use to monitor wellness, track conditions such as heart conditions and diabetes, contact a doctor online, record a variety of health-related data, and seek information. In the near future, we are likely to see versatile tools for diagnosing conditions such as skin cancer available on ordinary smartphones. At the same time, many elderly people are less prone to use new digital services and are risk of falling behind when the pace of technological advancements is rapid. Nonetheless, in the future, technology is likely to provide better support for the elderly, helping with medication and supporting increased mobility and autonomy.

Digitalization is both broad and deep. There is rapid development of software, apps, and AI programs, as well as improved hardware for different physical tools, ranging from robots for advanced surgeries to so-called "shower" robots that make daily life and hygiene easier for the elderly and those with physical disabilities. In this report, we are precise about what kind of technological development we are discussing when it matters for the context. Otherwise, we use the labels "robot" or "digitalization" to describe the general trend towards automation.

By and large, two aspects of digital technology are the driving forces of transformation in many markets and for society as a whole: network effects and economies of scale. With digital tools and platforms, it is possible to reach out to many users with services that are inexpensive or free, while the benefits for individuals who operate on the platform increase as more people join. An established platform that is open to developers can create even more significant

benefits for users which, in turn, increases the attractiveness of the platform. Although different companies have unique models and niches, these network effects drive almost everything that concerns digitalization and the economies of scale made possible by digital platforms.

The power of platforms with open API's is well illustrated by Apple. When the first iPhone was launched in 2007, the app store was initially closed to third-party developers. The iPhone would probably have achieved success regardless, but the attraction of all Apple products increased dramatically when developers could use their ingenuity to develop new services. With more apps, the platform became even more attractive to users, further strengthening the entire brand. When Apple opened up its app store on iTunes in July 2008, it only took nine months before a billion apps had been downloaded.[5] Together, Apple's app store and Google's equivalent store for Android devices created a new multibillion-dollar industry in just a few years.

There are many health care apps, but the effect of digitalization on health care goes well beyond them. Digitalization affects everything from work procedures to communication with patients. Digitalization can strengthen patients' knowledge and thereby reduce the asymmetry that has long existed vis-à-vis health care professionals. Social networks and grassroots initiatives strengthen patients and enable even those with rare diseases to connect with other patients with the same symptoms all over the world, sharing knowledge and experiences. Digital tools give more power to patients to monitor their health, and new opportunities for better preventive care.

This trend towards empowering individual patients follows a pattern found in other consumer markets, where digitalization has already uprooted existing power structures. But the demand for health care is large and growing, because of an aging population, and in Sweden and many other countries, it is financed mainly through taxes. These tensions and complications present challenges unique to the health care sector.

That technological developments can lead to improvement is mostly uncontroversial. The question is how great the improvements might be and what pitfalls exist. We see a particular risk that

[5] Isaacson (2011).

the elderly will find it difficult to use new digital services. One purpose of this report is to identify evidence of experiences of digitalized health care that have been reported in research in Sweden and in other countries. What effects are empirically established? We synthesize a large number of studies and highlight critical lessons.

Another purpose of our report is to place these experiences in a Swedish context, since a significant part of the development of health care digitalization so far has taken place in the United States. We also draw lessons from researchers' analyses of similar structural transformations in other sectors, identifying insights that are relevant to health care.

As in many other countries, health care in Sweden faces significant challenges as it copes with the increasing care needs of an aging population and the demands of citizens for quality and accessibility. Several studies have shown that the increase in welfare services spending that has been possible during the last few decades cannot continue without substantial increases in either productivity or taxation.[6]

Regarding the availability of welfare services, people increasingly expect to be able to communicate their health care needs in the same way they communicate needs in other areas – with a smartphone or computer, 24/7, through simple, user-friendly interfaces. In the future, this will apply to the young, so-called millennials, many of whom are digital natives. But the baby-boomer generation is currently approaching the age of 85+, when many begin to have much higher health care needs. One consequence is that Swedish health care and care for the elderly are facing a set of strategic choices. Among them, the question of how digitalization should be used should be central.

The easiest way for the politicians would be to continue on the same track as today, but this comes at a high risk of an unmet demand for medical care and a gradual erosion of what the public sector can deliver. To take advantage of digitalization opportunities requires major reforms that are currently absent from the policy agenda. It is not the sheer number of digitalization initiatives in the public sector that make an impact, but the quality: reforms should be strategically aimed at eliminating barriers to achieving network

[6] The Commission on the Future of Sweden, the Swedish Ministry of Finance's Long-term Scenarios, and the Swedish Association of Local Authorities and Regions' financial reports.

effects and economies of scale, while handling personal data safely. Our assessment shows that Sweden is in a very precarious situation when it comes to how much it stands to benefit from digitalization in health care. Innovations from private companies may be in jeopardy if politicians implement ill-conceived reforms.

In addition to synthesizing results from research on the effects of digitalization, we also give an overview of technologies and opportunities that have not yet been evaluated in scientific journals. More specifically, we give examples from newspapers and other media sources that provide glimpses into what is on the near horizon, including technologies patients have already begun to use, which have not yet been evaluated systematically by independent researchers. Admittedly, there is a real danger in getting caught up in the media frenzy about what may be possible. The sequence of events surrounding the company Theranos, in the US, provides one cautionary tale. Theranos grew quickly based on claims that their digital solution could deliver better and faster analyses of blood tests; these claims about performance turned out to be unfounded (see Section 2.6 below).

There are certainly some overly optimistic expectations about what digitalization can bring. However, it would be a mistake to confine our analysis only to established research. Technological progress is rapid, making it imperative to keep a close watch on technologies that may soon be realized and mass-produced. These issues are key, both for health care workers and for society as a whole. Indeed, citizens often choose health care as one of the areas of welfare that is most central for them. For this reason alone, there are crucial choices that must be made, in order to obtain the benefits of digitalization.[7]

In this context, we would like to emphasize that this review is an economic and financial analysis of how digitalization affects health care, not a medical evaluation. We do not claim to assess clinical efficiency or to evaluate different treatments. Much of the research that has been published about the digitalization of health care also addresses costs, quality, and other aspects that have a bearing on the social perspective that we are studying. We make a clear distinction in our discussion between research results that have been peer-reviewed and analysis from other sources, so that the reader can

[7] Ekholm (2017b).

distinguish between what has undergone scientific scrutiny and what is in an early phase of development.

The report contains a relatively large number of references. In order to make the material as accessible as possible, results are outlined in the text, with the support of summaries in tables. Table A of the appendix contains a complete summary of the research reports that we have synthesized in order to provide easy access to individual papers. In the various sections of this report, we also summarize the material in the context of multiple dimensions, such as effects on costs and quality.

The report concludes with our recommendations about what the pitfalls of digitalization are and what is needed to realize its benefits in health care.

2 Swedish health care and digitalization

2.1 High quality in Swedish care but recurring accessibility problems

Today, health care is one of the largest items in the public budget. Whether it's measured per capita or as a percentage of GDP, Sweden is one of the countries that invest most in health care.[8] In terms of quality, Sweden is ranked high in international comparisons:

- Cancer mortality and use of antibiotics are among the lowest.[9]
- There are more doctors and nurses per capita than in many other countries.[10]
- The proportion of patients abstaining from health care due to cost is low.[11]

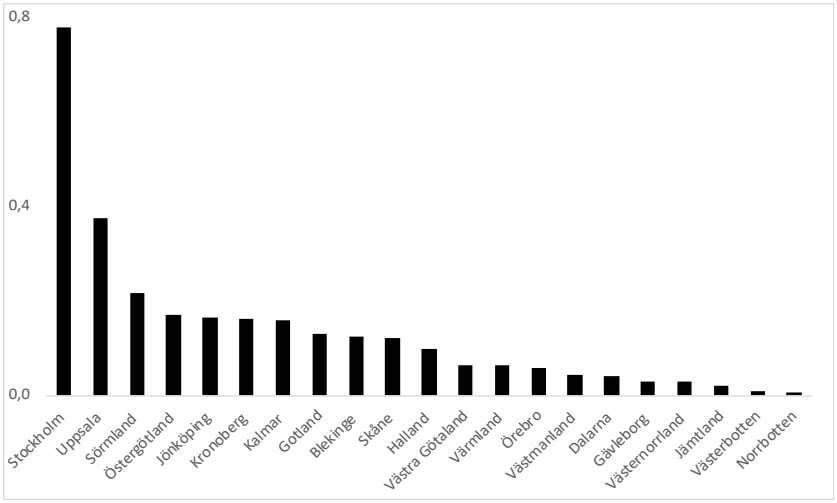
In a comparison of six common surgeries, Sweden does well in terms of waiting times.[12] However, when the perspective is broadened to include waiting times in general, and patients' experience of care, Sweden is among the least well performing countries.[13] When it comes to how much time doctors spend on patient visits, as well as patients' understanding of their treatments, Swedish health care is in the lowest third of OECD countries.[14] The elderly in Sweden tend to wait longer for treatment than in other comparable countries.[15]

[8] See, e.g., OECD (2017, pp. 133–135).
[9] OECD (2017, p. 57 and 103).
[10] OECD and European Observatory on Health Systems and Policies (2017, p. 7).
[11] OECD and European Observatory on Health Systems and Policies (2017, p. 11), OECD (2017, p. 91), Commonwealth Fund (2017, p. 5).
[12] SKL (2018c).
[13] Vårdanalys (2014b).
[14] OECD (2017, p. 101).
[15] Commonwealth Fund (2017, p. 7), Vårdanalys (2017, p. 36).

Lack of continuity in the care chain is a frequently mentioned problem and many patients lack a regular health care contact.

A fundamental feature of Sweden that affects health care provision is the considerable variation in the country's population density. This feature can be inferred from Figure 2.1. Some patients have to travel very long distances to get to the nearest primary care facility, and even longer distances to reach hospitals or specialist care. There is thus the all too pressing issue that those living in sparsely populated areas will refrain from getting the care they need. Over the years, various investigations have highlighted how health care can be better organized based on population and the size of regions, but the issues are complex, and gridlock prevents change on both the regional and national levels.[16] Here, digitalization could lead to significant improvements in accessibility, especially in sparsely populated areas.

Figure 2.1 Doctors in Sweden per square kilometer, regional level 2017.



Sources: SKL and SCB.

[16] One example is the so-called Ansvarskommittén (SOU 2007:10) which, in 2003-07, investigated the role of the State at the regional level, mainly focussing on health care needs, but which in large part did not receive any sympathy for its' proposals.

2.2 Digitalization and care: simple, complicated, or complex?

The strength of digital platforms comes mainly from two kinds of driving forces:

- Network effects, which give rise to higher benefits the more who join the platform.
- Scale effects, which make it possible to deliver comprehensive services at low or no marginal cost.

Almost all the benefits of digitalization across sectors are based on these two forces. They make it easy and inexpensive to reach a large proportion of the population with technology that automates well defined, predictable, and recurring tasks. The utility of platforms has been further reinforced by their attractiveness to app developers, who have created applications for a broad range of smart services, which in turn has attracted even more users. Such forces affect virtually all services – and so it is for health care.

Patients have different motivations and preferences that influence how and in what way they want to have contact with the health care system.[17] However, one convenient way to analyze the effects of digitalization is to divide health care into different categories based on their degree of complexity rather than based on characteristics of the patient (see Figure 2.2):[18]

1. Simple care is characterized by a clear, predictable, and repeated cause-and-effect relationship. For example, when someone has pain in his or her ear, it is often an ear infection. The task then becomes primarily about categorizing symptoms and following established routines.
2. Complicated care is characterized by a more diffuse cause-and-effect relationship, and symptoms may be delayed and require more extensive tests.
3. Complex care is more difficult in that it exhibits a more ambiguous cause-and-effect relationship.

[17] SKL (2018d).
[18] We adopt this characterization from Nilsson (2017, p. 13).

4. The chaotic domain, finally, exhibits great uncertainty and unpredictability, with no regularity and a lack of clear causations and correlations.

In this report, we will almost exclusively focus on simple and complicated health care, as the network and scale effects for these categories bring the most benefits.

Figure 2.2 Schematic illustration of health care and the degree of complexity.

Complex	Complicated
Chaotic	Simple

Source: Nilsson (2017, p. 13).
Note: This report mainly discusses simple and complicated care.

2.3 Digitalization strengthens patients

In the long term, digitalization can lead to significant changes in all categories of care. Several recent books and reports have argued that the power of health care will gradually shift from doctors to patients.[19] Some of this has already occurred. In the book *The Patient Will See You Now*, medical doctor Eric Topol argues that digitalization entails a form of democratization of health care. The same kinds of digital platforms that make it possible to match patients with services also create new and simple ways to communicate with them, and new ways for them – even those who exhibit unusual symptoms or illnesses – to communicate with each other. For example, patients exchange knowledge and experience via the web on US platforms such as *patientslikeme.com*, *curetogether.com*, or *insight.com*. Previously, the patient was mostly limited to what the treating physician knew or what the patient could find out in his or her immediate environment. Digitalization has lowered the bar for knowledge sharing among doctors as well. For example, on the Dutch site *ParkinsonNet*, doctors can easily exchange knowledge of treatments with other specialists.[20] And

[19] Kussin (2012), Mesko (2015).
[20] OECD (2016).

today patients can quickly and easily get in touch with specialist knowledge through various networks and channels.

The increased possibilities for patients also take other forms. Conventionally it has been primarily companies and universities that drive research and development, but now, in some areas, patient-driven innovation is beginning to emerge. What often drives such initiatives is frustration with a lack of expected support or help from health professionals. Through crowdsourcing, patients with programming skills develop and share apps and source code, working together toward automation and better treatment support for various diseases, diabetes being one prominent example.

The *Nightscout* project, in the US, was developed by and for patients to support the management of type 1 diabetes, and knowledge about diabetes treatment is exchanged in various other forums, such as *#wearenotwaiting*.[21] The majority of medical research is traditionally focused on clinical knowledge. Patient involvement is a relatively new and not wholly uncontroversial phenomenon.

One risk is that it may encourage unnecessary consumption of medicine if, for example, patients "shop around" among doctors or demand specific treatments.[22] Patients with chronic diseases may, however, become so-called "lead patients", who have more knowledge of their own care needs than doctors outside the specialty in question. There are several examples of patients who have succeeded.[23] In Sweden, surveys indicate that patients with chronic diseases feel they are not as informed or involved as they would like to be, compared to patients answering similar questions in countries such as in Switzerland, Holland, and France.[24] There is a great range when it comes to the information that patients receive about medicines, side effects and other symptoms. According to a survey that *The Commonwealth Fund* published 2013, Sweden is the worst in this regard and its difference from other developed countries in the OECD is quite large.[25] There are, therefore, several areas in which digitalization could improve health care in Sweden.

[21] Lee et al. (2016b), Omer (2016).
[22] Koivisto (2017b).
[23] Topol (2015), Riggare et al. (2017).
[24] Vårdanalys (2014a, p. 93).
[25] Commonwealth Fund (2017).

There is a concern that older people often are less able to use new digital services. One estimate is that 400,000 older people in Sweden are mostly excluded from digital care because they lack a computer or an internet connection.[26] Another concern, mainly from within the medical profession, is that patient empowerment can lead to an increase in incorrect diagnoses and related undesirable effects.[27] There are even indications that lead patients may hold back on their knowledge in their dialogue with doctors in order not to be regarded as "troublesome."[28] One study in diabetes care shows that resistance from within the medical profession can sometimes be strong enough to reduce the benefits of greater self-care or even remove them altogether.[29] However, other research shows that more involved patients tend to be better at following treatment protocols in cancer care and pharmaceutical studies. This results in higher medical benefits and reduced investment uncertainty, improving the conditions for clinical research in the long term.[30] Conversely, there are estimates based on a US study of approximately 33,000 patients indicating that unmotivated patients cost more than 20 percent more than patients who take active responsibility for their care.[31]

Broadly speaking, digitalization has enabled patients with chronic illnesses to take greater control of their health. A meta study of research into the management of pain through online forums, for example, showed that social networks on the internet have for many years played an essential role in facilitating self-care and managing intense pain, notably among children.[32] In Sweden, a new project is underway with a focus directly on lead patients.[33] In some cases, digitalization makes it easier to use a technology that already exists, such as the self-dialysis at the Ryhov regional hospital in Jönköping, where patients receive ID-cards and can control the times of their visits, exercising greater control over their treatment. This makes a big difference for patients, especially for those who visit the clinic several times a week, because a dialysis treatment can take several

[26] Olsson et al. (2017).
[27] Lee et al. (2016a).
[28] Frosch et al. (2012).
[29] Snow et al. (2013).
[30] Levitan et al. (2017).
[31] Hibbard et al. (2013).
[32] Bender et al. (2011).
[33] http://dagenspatient.ringla.nu

hours.[34] Other regions have developed various forms of "home dialysis", such as one program through Stockholm's Danderyd Hospital, as well as in Lund, the Västra Götaland Region, and Örebro. Overall, the possibility of expanding self-dialysis is progressing slowly, but across the country, several different projects are running.[35] Karolinska University Hospital in Stockholm has developed an app for children with diabetes, and the Region Västra Götaland has self-testing for patients with inflammatory bowel disease (IBD).[36]

Of course, self-care is not new, and for many years, patients have been able to call their region's toll-free number to receive medical advice from a nurse or health care professional via telephone. However, digitalization facilitates taking self- and preventive care to the next level, with varying degrees of contact, support, and follow-up from health care professionals.

Indeed, thanks to the whole range of new technologies, from self-dialysis in Ryhov to digital tools developed by large companies as well as small players, digitalization improves patients' ability to be in control of their treatment. Smartphones and web solutions provide tools for health and medical applications that add value for consumers and, of course, also take advantage of potential profits in the health care sector, generating billions of dollars of revenue every year. For example, in 2017, Apple developed a health care app that enables the collection of various forms of health data, such as cholesterol and blood pressure, which developers can use to design digital care services and offer tailor-made advice on how to improve health.[37] Such an app offers new opportunities for patients to monitor their health and, where appropriate, take preventive measures in terms of diet, exercise, or early medical treatment.

Apple's health care app is intended to allow communication between patients and doctors. However, so far, this is only planned for the US. Another part of Apple's plan for expanding into health care is the company's *ResearchKit* that will make it easier for doctors

[34] Koivisto (2017a).
[35] Cederberg (2018).
[36] Karolinska (2015), VGR (2017).
[37] Singer (2018).

and researchers to interact with patients using apps.[38] IBM has also developed several health care applications, including Watson, which is a tool with applications in several areas, including the detection of cancer. IBM also works with AI to evaluate whether spoken language can provide indications of impaired mental health (more on this below).[39]

There are also platforms that can help in emergency care situations, where early and rapid interventions can make a crucial difference. Many travelers can probably recall situations when staff over a loudspeaker asks passengers if there is any doctor on board who can help. Some entrepreneurs have, in some sense, automated such calls for help in order for emergency care to be less dependent on happenstance. For example, in London, there is an app called *GoodSAM*, which not only contacts emergency services when needed but also automatically examines whether there are qualified health care professionals nearby.[40] This technology can be of crucial importance when the time is of essence and every second counts, for example when a person stops breathing or experiences the onset of a heart attack. The app *Mobile Retter* does roughly the same thing in Germany.[41]

Digitalization probably has significant potential to increase health awareness and improve the outlook for preventive measures. It is rather hard to exaggerate the importance of early and preventive actions for the individual and, in the aggregate, for society as a whole. One area that illustrates this is cardiovascular disease, which leads to massive inconvenience and suffering. Notably, a Swedish report calculated the total socioeconomic cost of heart disease to be SEK 61.5 billion in 2010 (or about EUR 6 billion), which is roughly as much as what the national government (over and above that spent by the regions) spent in the same year on health care in their budget[42] or the equivalent of two annual total outlays for all medicine collected in pharmacies under the state subsidy program in 2017.[43] The *indirect* costs represent approximately 60 percent of the total

[38] Apple, for example, sponsors an ongoing study of 500,000 people in order to see if iWatch can be used to measure heart problems, https://clinicaltrials.gov/ct2/show/NCT03335800?term=apple+heart&rank=1.
[39] https://futurism.com/ibm-psychosis-predicting-ai-speech
[40] https://www.goodsamapp.org
[41] http://www.mobile-retter.de
[42] Steen Carlsson and Persson (2010).
[43] Socialstyrelsen (2018b, p. 23).

amount and are thus substantially larger than the *direct* spending. Indirect costs are those that arise from the loss of production, the need for support from relatives, early retirement, and shorter life expectancy.

When they offer early and continuous follow-up, digital tools and apps can create the conditions people need to follow through on preventive measures, such as changing their diets and exercising more. However, the potential benefits of using digital aids to monitor personal health do not always translate directly or automatically to improvements, and there are some obstacles. In the US, blind people have been able to take part in digital communication through digital assistants, including Amazon's Alexa. There have also been experiments with remote navigation assistance for the blind, in which blind persons were equipped with Google Glass so that staff could guide them from a distance.[44] One difficulty that emerged was that to deploy today's digital technology effectively requires some prior knowledge and skills that to varying degrees may be absent among the blind or other disadvantaged groups.[45] However, at the very least, technology can eliminate some obstacles and provide conditions for better awareness of personal health. How much health improvement will be realized is an open question.

Digital watches and similar instruments have been available for several years, but knowledge of behaviors and patterns is continually evolving. If, on the one hand, an individual entirely lacks digital aids for health – not unlike the situation over a decade ago – it is entirely up to the individual to assess whether their own care needs require contact with the health care system.

In some cases, health problems may become severe before the diagnosis or action is taken. Some people may be in the habit, for example, of ignoring warning signs of health problems until they become severe, instead of taking early preventive measures. Digital measurement of personal health throughout the day is the polar opposite of ignoring symptoms, as it enables comprehensive real-time monitoring, either through a software robot or through a human-staffed online health care center.

Some aspects of measuring personal health have the potential to be positive, such as knowing the number of hours one has slept,

[44] Donahue (2017).
[45] Bogost (2018).

one's heart rate during different types of physical activity, or one's blood pressure. However, it is not difficult to imagine a temptation to overconsume digital health information. Deviations from typical values or other warning indications do not always have to be meaningful, over shorter periods. Even over more extended periods, not all changes need be a cause for concern. There is a risk that some people will overinterpret the vast amount of information, which in itself risks creating anxiety.[46]

Many of the first-generation measuring instruments were of low quality.[47] A few years later, technology and knowledge have taken several steps forward.[48] A 2018 report on the experience of 24-hour digital surveillance over the course of a year demonstrated several positive experiences of the new generation of digital measuring instruments.[49] However, it also showed that a lack of context for understanding data sometimes becomes a hurdle. Large amounts of information without a recognizable context (or reference point) can be counterproductive or demotivating. Systematic studies in this area do not yet provide precise results. One report finds weakly positive effects of digital watches.[50] Based on a survey, Garner (a consulting firm) emphasizes that about a third of users do not find digital watches usable.[51] However, developments are rapidly advancing, and studies from only a few years ago no longer carry the same relevance. Exactly how people will react in the presence of an abundance of personal health information remains unknown.

2.4 How we have made the selection of research articles

Digitalization in health care has grown into an immense area of study, with many reports and studies, from those with rather narrow perspectives to those that take a broader outlook. We have imposed a limit and excluded all studies published earlier than 2010. The choice of this year as a cutoff point is not an assertion that earlier studies lack value. For one, research reports usually include or

[46] Song (2018).
[47] Duffy (2015).
[48] Krohn and Metcalf (2016).
[49] Song (2018).
[50] Gierisch et al. (2015).
[51] Gartner (2016).

assimilate already published results. For practical reasons, however, we need to make the material manageable. The year 2010 does not signal any specific event but can be seen as an approximation of the start of a new wave of digitalization through the smartphone revolution.

Even with this limitation, our report, while exhaustive, cannot cover all the available material. To select the studies that form the basis of this report, we searched databases and drew on other surveys and studies to find the most relevant and trusted sources.

One challenge in including new digital methods or apps is that they are not systematically evaluated, at least initially. Moreover, there are commercial actors with interest in exaggerating results and applicability. Notably, there is often no easy way of applying a placebo to gauge the effectiveness of an app. One implication is that it is then not possible to apply powerful statistical concepts, as these often require that the selection between the treatment and control groups to be randomized.[52] This is a serious limitation that means other ways of evaluating the technology must be used to ensure that the results are reliable.

We are also aware that there may be a risk of bias in the literature, which stems from the fact that it is probably easier to get a report published that finds a clear effect rather than the opposite. There is no easy way to get around this problem.

We mitigate the potential problem of positive publication bias in several ways. Our report is based mainly on scientific articles that have undergone peer review, which is an established form of quality assurance in the sense that results and arguments are critically reviewed by other researchers with expertise in the field. In our analysis, we place particular emphasis on articles published in high-ranking journals, as these espouse particularly high demands on rigor, relevant data, well-substantiated conclusions, and other aspects of scientific quality.

Though it would be simple to exclude all articles that have not undergone peer review, this would curtail the relevance of the report, as the peer-review process is lengthy while technological advancements in digitalization are rapid. Our analysis is based mainly on articles in highly-ranked journals, but we do not exclude other sources when we judge that the arguments have merit. We believe,

[52] Lipschitz and Torous (2018).

however, that it is essential to distinguish between peer-reviewed work and other sources. The text does this by characterizing a study as a leading study or as being comprehensive. The compilation of the research review also lists the articles published in journals that are ranked highly according to the Web of Science (see Appendix). Our assessment of the articles relates above all to their relevance for our study and the arguments we pursue.

There is certainly a possibility that we, as authors, have made biased selections, perhaps above all by classifying some digitalization effects as more groundbreaking and promising than is the case. In order to reduce this possibility, we are also careful to report studies which, where appropriate, show no or negative effects, and we pay particular attention to the risks and missteps that digitalization may entail (see Box 1). In Tables 5.1 and 5.2, which provide an overall summary of the cost and quality effects, the leading studies are reported in boldface; this is to convey not only the number of reports that feature a particular result but also the quality.

We have also placed particular emphasis on understanding why the effects of digitalization are positive or negative in the studies we have reviewed. The main message from each report is summarized in Appendix, partly for ease of reference and partly because of the insights in some instances point to pitfalls that should be avoided or lessons to be taken.[53] For example, one highly ranked study finds that electronic health records have so far garnered only modest savings, and this underlines the importance of supporting such a system with organizational change.[54] How we use this study illustrates our approach to being as fair as possible while presenting a vast and fragmented field of research: we find the conclusion of modest savings is a relevant and noteworthy observation – something that we choose to highlight as a key finding that should be considered (see further Section 2.9).

Finally, as a matter of transparency, we wish to emphasize that we fully report both positive and negative effects of digitalization, but that the overall assessment of the material is our reading of the literature and is based on *our* collective experience of the research and our understanding of the societal impact.

[53] In Table A of the appendix, studies from highly ranked journals are listed in the (last) column rank named "HR", and the author name (first column) is also in boldface.
[54] Adler-Milstein et al. (2013).

2.5 Robots are getting better

In the economy overall, there has been extensive polarization whereby middle-level jobs are either moved down the skill ladder or else become more advanced, requiring stronger skills.[55] Digitalization will speed up this process further, but most arguments do not provide support for dystopian visions of disappearing jobs in the economy – or in the health care sector.[56] Some technology will initially reduce the physical aspects of some care as well as provide more autonomy to patients, as with, for example, the use of so-called "shower robots" in elderly care. The implication is that health care professionals can devote themselves to other tasks, such as the more social aspects of their work or to following up on care. However, rapid technological progress means that skills become outdated quickly, and knowledge needs to be updated. Even for medical doctors and others with long years of training, it will be a challenge to keep up with the robots.

In several specialist areas, software robots are becoming increasingly sophisticated. Drawing on mathematical principles and with the help of so called neural networks (convolutional neural networks or CNN), software robots are "trained" to recognize diseases from extensive databases of images. Although the mathematics is advanced, even researchers without specialization in programming can take advantage of existing software libraries and knowledge bases, allowing for easier and faster deployment of technology into new fields of application.[57]

Advances in the use of robots have been made in several areas of medical research. The technology has become remarkably good at identifying different forms of cancer and risk factors such as blood clots. The robots now perform as well as medical doctors – and in many cases better than them – when it comes to identifying a disease on the basis of an image.[58] Notably, a study published in the journal *Nature* found that robots classified kinds of skin cancer just as well as specialized dermatologists did, when asked to examine the most common form of skin cancer, as well as the one with the highest

[55] Goos et al. (2014).
[56] Autor (2015).
[57] Erickson et al. (2017).
[58] Nguyen and Patrick (2014).

mortality rate.[59] The software to accomplish such analysis may soon be available in regular smartphones. A study in another prominent journal shows that a smartphone app can make better diagnoses than doctors for some specific arterial diseases.[60] Similar results were found in another study, where the software was just as good at finding lung cancer.[61] In another study on identifying skin cancer, the software was superior to specialists.[62] Robots are also as good, or better, at correctly identifying eye disease.[63] For tasks where data essentially needs to be compared to a large knowledge-database, the software will gradually expand in scope and depth.

Some companies have been pushing the forefront in AI-applications. IBM Watson has developed a system that can be used, among other things, to assess the risk for cancer. However, there are also critical voices.[64] Some well-established AI researchers argue, notably, that the technology is overrated.[65] At the same time, there are areas where AI has already surpassed human capacity. It was many years since a human alone could win against a computer in chess. In 2017 Google Deep Mind took another big leap in showing that the computer could win against the world's best player of *Go*, a popular Asian board game that is simple to play but contains even more variation and complexity than chess.

IBM's Watson technology has already been exported to countries outside the US, and one conclusion is the importance of taking into consideration the local language used by doctors. Another example of diagnosis with AI and machine learning is the Google Deep Mind project at Moorfield's Eye Hospital in the UK. Through automated assessments of images of the eyes, diagnosis can be made much faster, saving doctors many hours of work.[66]

This pattern of improvements is similar in kind to those we see in other parts of the labor market, for example, for journalists. At first, robot-texts were somewhat stale, but they have now improved to a point where they are difficult to distinguish from those written

[59] Esteva et al. (2017).
[60] Di Santo et al. (2018).
[61] Wang et al. (2017).
[62] Haenssle et al. (2018).
[63] De Fauw et al. (2018).
[64] Gorski (2017).
[65] Davies and Marcus (2016).
[66] De Fauw et al. (2018).

by a human hand. This development is particularly evident in areas such as news summaries, most notably with sports results, newly released economic statistics, and company earning reports.[67] Humans can no longer compete against robots when it comes to writing speed, but are still better at providing depth, inquisitiveness, and reflection. The result – mirroring developments in the whole labor market – has been increasing pressure on those with "ordinary" skills, while the best are propelled upwards on the earnings ladder in their various professions, as journalists, lawyers, professors, or financial analysts.[68]

As regards health care, it is fruitless to guess the precise way in which machines will infringe on various specialist occupations. However, it is not unlikely that robots will soon be superior to humans in areas where diagnoses require the input of large amounts of data. Also, robots tend to be much faster, which can be crucial for successful treatment in environments with frequent time pressure.

At first, a digital technology is likely to serve primarily as a complement – a powerful tool among others. Scientists have developed minuscule robots that can travel through tissue and will perhaps in the future deliver medicine directly inside the body with high precision and fewer side effects.[69] In other areas of health care, robots are used as a complement to create new forms of treatment and increase precision in existing ones. In brain surgery, for example, 3-D technologies are used to create detailed images of the brain, facilitating surgery and reducing staff workload.[70] Technologies can also be used to improve training. Moreover, primary care providers have access to more powerful digital tools, which can also be used in places where doctors are scarce or where advanced laboratories are unavailable, such as in developing countries or areas affected by wars or natural disasters. Notably, a general practitioner can have easy access to a specialist via a video link.

However, the pursuit of speed and efficiency can increase the vulnerability of the health care system in ways that are difficult to predict. As technologies become more accessible and easier to use,

[67] For an overview, see Blix (2016, p. 125). There are also many competitions, eg. Sara Connor at the Financial Times competing against the robot Emma, https://www.ft.com/content/92583120-0ae0-11e6-b0f1-61F222853FF3.
[68] Cowen (2015).
[69] Hu et al. (2018).
[70] Grady (2017).

there is a risk that they will be used in inappropriate situations, or by non-experts who pay no heed to warning labels. This does not mean we should curb the advance of digitalization, but underlines the need for health care regulators to monitor ongoing development, and for those in the medical profession to update their skill set.

In some specialist areas, robots may, in the future, be able to substitute for the work of doctors. Even in situations where robots impinge on the role of humans, though, this does not mean that robots are ”taking over”. For most health care professionals, there are legions of other tasks that they can do instead. However, in interpreting pictures, the robots are beginning to gain the upper hand, creating an increasingly vigorous competition for human doctors. This development points to the need for a strategic plan within the medical profession for updating skills to mitigate or avoid the risks of polarization in the profession.

2.6 Gap between the government's e-Health vision and today's IT systems

While the research front is rapidly advancing with automated diagnoses, machine learning, and AI, Sweden's existing IT systems are sluggish and have a host of compatibility issues. There will be much work to replace so-called legacy systems with the new ones that are now technologically possible.[71]

The gap between the government's e-Health vision and reality is, in some cases, disturbingly large. There are reports from the nurse's trade union (“Vårdförbundet”) that show that the regions are not good employers and often fail to prove the support that the staff is asking for. Existing systems are perceived as lacking in user-friendliness, and there is also frustration with overdocumentation.[72] Instead of making work easier, existing systems often add to the workload.

Getting health care professionals on board with the implementation of digital technologies is crucial if digitalization is to succeed. Unlike in some other areas, there is no shortage of work to be done in health care. However, the public sector needs to ensure that staff

[71] A legacy system is an older technology, which is often difficult or risky for a business to change because it can contain sensitive functions or essential data.
[72] UsersAwards (2010).

is given sufficient time and support to learn how to use the systems and technologies available. The Swedish government's ambition to have the best e-Health in the world is but an empty slogan if it is not followed up with content and concrete support for those in the health care profession as they implement technological change.

2.7 Risk for missteps

Technology leads to many improvements, but there is no shortage of unrealistic expectations.

One of the major flops in bringing digital technology to health care has been the US company *Theranos*. On the hope that a minimal blood test would be sufficient to extract precise and quick results from a central digital database, *Theranos* lured large investors to get on board with their money or lend prestige to the project. The technology raised high hopes that it could spare patients the physical discomfort of blood tests and provide blood analysis in inaccessible places without access to laboratories, such as rural areas, developing countries and war zones.

In total, *Theranos* managed to raise more than USD 700 million and was at one point valued at USD 9 billion.[73] Politicians, investors, and celebreties were enthralled. The enticement was that Theranos digital technology would revolutionize health care and thus follow in the steps of Silicon Valley companies that had successfully disrupted other markets. Subsequently, it turned out that the test results were of poor quality and may have been fraudulent.[74] The Theranos management is now accused of various irregularities and subject to legal action.[75] In the US, there have also been various other mistakes in digital health care, including the improper prescription of medication due to errors in automated routines.[76]

Personal data can be used in many inappropriate ways, and numerous dangers can arise. As the historian Yuval Noah Harari emphasizes, the technology is itself inherently neutral and can be used for both good and bad things, such as intrusive monitoring of

[73] Topol (2018).
[74] Carreyrou (2018).
[75] Shubber (2018).
[76] Wachter (2015).

citizens.[77] The American medical doctor Eric Topol also warns against the effects of personal health data in the hands of for-profit companies.[78]

In Box 1, we summarize some incidents where personal health data has landed in the wrong hands, but also other types of serious incidents.

Box 1. Examples of vulnerabilities from digitalization.

Digitalization offers many advantages, but it is essential to be aware of the various risks and costs that can arise. Unless these are addressed and preventive measures are taken, the benefits of digitalization may decrease – or be altogether absent. Societal confidence in digitalized health care is affected by how well sensitive data is protected. For example, if an authority leaks sensitive personal data, citizens may be more skeptical about entrusting their data to all other areas of the public sector.
Here are some examples of incidents:

- Fraudsters used the virus *WannaCry* for extortion by exploiting loopholes in an older operating system. Companies and organizations across Europe got their computers locked and were asked to pay ransom to re-access their data. Many people and companies suffered worldwide, but the UK National Health Service (NHS) and several of its hospitals were hit especially hard. Thirty-four (34) percent of all local health organizations (trusts) in the NHS were affected, which resulted in approximately 19,000 canceled patient visits.[79]
- The credit information company *Equifax* in the US was exposed to one of the most extensive hacking attacks in modern times.[80] Credit card numbers and other sensitive information for about 200,000 people were stolen, and a total of 143 million Americans were affected. Some of the information was particularly sensitive, such as social security numbers. Should personal health data be exposed in the same way, the damage could be even more severe, and confidence in vital societal functions would be undermined.

[77] Tett (2018).
[78] Wilbanks and Topol (2016).
[79] NAO (2018).
[80] Bernard et al. (2017).

- The network server crashed at the *Nya Karolinska* Hospital in Stockholm. The cardiology department at the hospital had problems with telemetry for monitoring of heart patients, and the hospital had to implement emergency protocols.[81]

On the one hand, there are substantial potential gains in society from digitalization, and on the other, there are significant costs if the privacy and confidence of vital societal functions are undermined through disclosure of personal data. Weighing the risks and benefits of data use is to some extent a political issue, but, so far, personal integrity has been given the most emphasis in Sweden and in Europe, which has been further reinforced by the decision by the European Union to implement the general data protection directive (GDPR).

The Swedish government's decision in 2018 to establish a national pharmaceutical register in 2020 also emphasized personal integrity, specifying search restrictions, active consent, and blocking.[82] Strong privacy protection comes not only from individual government bills but also from how existing rules are applied in each area. It leads to difficulties in developing basic data for the implementation of distributional and budget analyses of policy measures, particularly in the field of health care and pharmaceutical pricing – for researchers, relevant authorities and also for officials in government offices.[83] One report notes that there is a lack of good knowledge of possible personal integrity costs, as well as the benefits of digital care, and emphasizes the need to weigh these against each other in an overall assessment.[84] We fully support this argument and one aim of our report is to increase the awareness of the potential benefits of digital care.

2.8 Treatment at the right level and e-triage

Studies and reports on Swedish care often emphasize the importance of patients being treated at the right level in the health care system.[85] In many cases, this implies that patients should be treated in the

[81] Lindström (2017).
[82] Regeringen (2018).
[83] Ekholm (2017a).
[84] Vårdanalys (2016, p. 10).
[85] Vårdanalys (2014b).

primary care system. Both tax- and insurance-financed systems need some form of rationing to be financially sustainable. In the Swedish system, the medical need of the patient should be the main factor, and for this to be possible there needs to be careful triage of patients – that is, an assessment and treatment of patients based on medical priority. Otherwise, the queues will grow, and it will be difficult for those with the greatest need to receive the care they need. Also, when patients have difficulties in accessing the health care system, they are more likely to seek out emergency care, which is more expensive for society and also poses potentially significant risks and hazards for those in a real emergency.

In triage, it is necessary to make decisions based on an adequate medical history of the patient's condition. Digitalizing this information can generate significant improvements in efficiency. When the doctor can focus on follow-up questions or respond to concerns raised by the patient rather than on ticking bureaucratic boxes, the time and quality of the treatment can improve. Although medical history takes a significant part of regular medical visits, there are still indications that the information is at times inadequate. One study indicates that in over 75 percent of 213 hospital records completed, there was important information missing that was necessary to apply the established guidelines.[86] Digitalizing medical history is a simple enough measure, but we believe that it can provide significant time and cost savings.

Triage has always been critical but has recently increased in importance with the advent of telemedicine doctors (discussed further below). Telemedicine and the advent of AI in health care also raise new issues about the extent to which a regular triage performed by human health professionals, i.e., doctors or nurses, can be supplemented – or even replaced – by a digitized version, i.e., by a robot. Already today, patients fill in their digital medical history in advance of telemedicine care, but it is also used by other private health care institutions, such as *Capio*,[87] which combines telemedicine (through web chats) with the possibility of physical visits to its health care facilities, or *Familjeläkarna*[88], which provides small- to medium-sized health care-centers in the Stockholm region. In its

[86] Zekim et al. (2014).
[87] https://capio.se/capio-go/.
[88] http://www.famlak.se.

most basic form, a digital medical history replaces the standard questions posed to a patient, but it can gradually be made increasingly intelligent and sophisticated. The technology makes it easy to set logical supplementary questions and also to take pictures. Digital medical history can thus be more content-rich as well as more interactive, and ultimately form the basis for automated – or robotic – assessments.

Being assessed by a robot may seem strange in general, and in health care in particular, but automated assessments are already a reality.[89] In the Swedish municipality of *Trelleborg*, for example, the decision to grant economic aid through social services is now mainly done by a robot. The result has been that social secretaries have been able to devote more of their time to meetings that require human contact and less on simple bureaucratic work.[90] Some government agencies have taken steps in the same direction. Through more automated routines, the Swedish Social Security Agency ("Försäkringskassan") has increased the satisfaction of its users and at the same time reduced the cost of managing the service by about 36 percent.[91] It is often possible to achieve significant savings in this way because human labor is expensive compared to software robots, which can work 24/7.

The assessments made by a robot can provide many other benefits: The robot is never tired or in a bad mood, and it follows its preprogrammed rule book. In other contexts, there have been fears that automated assessments reflect society's existing prejudices, including racism, sexism, and age discrimination. For example, human resources (HR-functions) have evaluated job candidates based on past correlations in data, which entails a risk that existing labor structures are reinforced and that groups that are subject to discrimination in an analog environment also continue to be discriminated against by automated services. In other words, there can be a form of more or less unintentional discrimination as a result of opaque mathematical calculations.

For automated (or robot assessments) to be legitimate, it is crucial there be no hidden discrimination or agenda. However, it should be possible to reduce the risk of discrimination in e-triage

[89] Loder and Nicholas (2018).
[90] Adolfsson (2017).
[91] SKL (2018b, p. 22).

through how the robot is programmed. We should also demand that the robot be asked to justify or explain its assessment in a transparent manner. This justification should be a crucial issue for legislators and authorities, who should take steps in this direction as soon as possible. Retroactively enforcing this type of requirement is much harder, and good standards are likely easier to establish in the early stages of AI-developments.

It is not a simple task to evaluate robot assessments or e-triage, but there is some experience from various studies in the health care system.

Results from research

A pilot project in Scotland led to improved treatment of eye conditions. E-triage increased the accuracy with which patients were matched with specialists, significantly reducing the risk of blindness; median wait times decreased from 14 to 4 weeks.[92] Another project demonstrated that e-triage led to better control of sexually transmitted diseases (STDs), as well as better follow-up, and that patients welcomed the change.[93] In a study of e-Referral in rheumatology, electronic forms and devices led to electronic medical records that provided a better basis for communication among doctors and improved triage of patients.[94] There are also AI-tools based on patients' spoken language that can be used to triage mental illnesses, such as incipient psychosis. Although the number of patients was relatively small, results from a leading study show that e-triage accurately finds signs of incipient psychosis in just over 70 percent of psychotic patients, compared to healthy subjects.[95]

Results from news media and web pages

In the simplest method of digital triage, patients themselves fill out an electronic form and recommendations for care vary according to their answers. *Min Doktor* in Sweden has already developed such functionality in their app, which is currently mainly focused on

[92] Khan et al. (2015).
[93] Jones et al. (2010).
[94] Scheibe et al. (2015).
[95] Corcoran et al. (2018).

dealing with simple medical problems. If the patient does not have a clear medical need, or if the diagnosis cannot be made remotely, the app does not result in a medical contact with a doctor but instead gives some form of advice. In the UK, the private digital health service *Babylon*, available through a smartphone app, has taken some additional steps and developed a specific form of AI-assessment of patients. The Swedish firm *Doktor24* has also taken steps in this direction.

It is too early to assess how well these e-triage systems work. There is a risk that patients with an intent to deceive the system will learn what answers are required to get a telemedicine contact with a doctor. This risk has always been a possibility with physical health care visits, where some patients may try to adapt their responses to what is required. The significant difference with digital care is that it is much easier to initiate a request from an app in the smartphone than to physically get to the nearest medical center.

Similarly, there is a risk in the opposite direction, i.e., that patients who downplay their symptoms or respond "too honestly" are not put through. It will be a challenge to balance between these different extremes. *Babylon* (in the UK) has in 2018 been criticized because potentially severe symptoms of blood clotting and heart attack did not lead to an urging to seek emergency help.[96] It is possible to make many objections to an automated e-triage system, but a robot only does precisely what it has been programmed to do, only faster and at low marginal cost. If health care queues can be reduced by the automatic sorting of many patients with simple needs, those requiring more care can be better directed to the appropriate place in the health care system. To the best of our knowledge, however, there is no such system in place – but at some point, it is likely to come.[97]

2.9 e-Journals

The technical feasibility of introducing e-journals has been around at least since the 1990s. When doctors have access to e-journals from other county councils or municipal elderly care services, they can

[96] Ram and Neville (2018).
[97] Loder and Nicholas (2018).

provide many benefits. In an extreme situation, when a patient is in a critical state and unconscious, such information can be vital. For patients with more ordinary health care needs, the e-journal can save time. For chronic patients with many care contacts, it may be stressful, for example, to have to repeat their own (complicated) history several times, especially if they have to meet with several different doctors.

E-journals have long been available only to doctors. In Estonia, patients have since 2008 been able to read their e-journal online. In Sweden, however, this was initially a deeply contentious issue (see Box 2). There were concerns in the medical profession that patients would misunderstand the medical notes and that the e-journal would cause unnecessary anxiety. There was argument about the risk that sensitive data could be disseminated to unauthorized persons, or be abused by relatives. And there was concern that e-journals would diminish in value as work-tools if doctors began to censor themselves in their notes.

After much legal wrangling and effort, however, many regions have made it possible for the patients to read their e-journals, giving them the advantage of not having to wait for a message and the ability to better prepare for the next meeting with their doctor. Some patients prefer to quickly be informed even if there is a risk of misunderstanding or if the context is unclear.[98]

Box 2. Resistance when e-journals were introduced in Uppsala.

The need for patients to access their own e-records met with strong legal and bureaucratic resistance.[99] The Uppsala region was possibly the first in Europe to introduce e-journals that patients could read, but the initiative did not come from the region or politicians.[100] Instead, a local initiative by an enthusiastic IT technician, Benny Eklund, initiated a project with support from the county council in 1997.[101]

When the media reported about a patient who had access to his e-journal, the Swedish Data Inspection Authority ("Datainspektionen") initiated a review of the case. It concluded

[98] Grünloh (2018).
[99] Grünloh et al. (2016), Grünloh (2018).
[100] Mellgren (2013).
[101] Erlingsdóttir and Lindholm (2015).

that the project was in contravention of existing legislation and ordered an immediate cessation. The decision was subsequently appealed, but it was not overturned, and the judgment became final. Nevertheless, the project continued to explore the usefulness of e-journals by continuing instead as a research study, which qualified for an exemption from the law. Only in 2008 was the legislation amended, allowing e-journals.

In 2012, a conflict arose with the local doctors' association in Uppsala. More legal wrangling ensued, and the launch was postponed for a few months. More than five years later, all regions in Sweden have e-journals, but the degree of access varies, as does compatibility among different systems. The National Board of Health and Welfare ("Socialstyrelsen") has also noted that health care staff in nursing homes, for the most part, lack access to electronic patient information.[102]

Research into the use of e-journals in Canada indicates good experiences in terms of communication among doctors and between doctors and patients.[103] Surveys from several countries show concern among doctors, but patients are more satisfied.[104] A leading study concluded there were no overall cost savings, but found that access to e-journals reduced the need for diagnostic testing and improved adherence to emergency care guidelines.[105] An extensive US study of 119,000 patients in 32 hospitals showed that digitalization reduced mortality in intensive care by making medical data more quickly available and improving adherence to guidelines.[106]

One difficulty is that experiences from different systems and other countries are not directly transferable to Sweden. It is difficult to measure quality improvements and, despite several positive results, the literature often gives a fragmented picture.[107] Administration and follow-up with patients are improved, but if existing work practices are not adjusted, the workflow will not

[102] Socialstyrelsen (2018a).
[103] Jackson and Bradley (2014).
[104] De Lusignan et al. (2014), Mold et al. (2015).
[105] Bailey et al. (2013).
[106] Lilly et al. (2014).
[107] Davis Giardina et al. (2014).

improve.[108] A study underlines that cost savings of e-journals have so far been modest and concludes that for more significant improvements, organizational changes are required.[109] We believe this is also true for Sweden.

Crucial innovations in the private sector

Apple is in many respects an admired company, and in 2017 it became the first in the world to achieve a market valuation of over USD 1 trillion, that is, about twice the total of Sweden's GDP. Even if Apple had not opened its app store to outside developers, it is likely it would nevertheless have succeeded. It is crucial that private innovators are allowed to disseminate and realize their ideas.

Our overall assessment is that the full potential of e-journals is achieved only when there is a way for individuals to give their data to private providers, who have the ability to provide various services linked to that information (via open API). In the section below on chronic diseases, we report an example where a private actor in Sweden (*Coala*) offers heart monitoring. Related services that provide various means of monitoring of other diseases, such as diabetes or cancer, could be linked to a patient's e-journal. However, it cannot be assumed that the regions will be the driving force behind such innovations. History shows that it is private companies and patient groups who are at the forefront of developing and providing new services. What is crucial to the success of e-health is whether there is an established platform that entrepreneurs can communicate with and on which to build services on.

[108] Nguyen et al. (2014).
[109] Adler-Milstein et al. (2013).

3 Simple care

"Simple care", in this context, means neither that the health care need is minor nor that treatment is trivial. Instead, it means that the link between cause and effect is relatively clear and well understood. Below, we discuss some results from the research literature on digitalization for simple care. A summary is also available in Table 4.1, later in this report. Table 4.2 summarizes results from news media and web pages.

3.1 Telemedicine

We use "telemedicine" as a collective term for situations where a doctor or psychologist is in contact with a patient via video link, email, web, or phone, rather than in a direct physical meeting at a hospital, health center, or at home ("nätläkare"). It can also refer to a health care contact with a nurse. For our purposes, the important distinction is whether the meeting is held remotely or in a physical space.

In a direct meeting with the patient, the doctor has the opportunity to do a physical examination, which provides conditions for making the correct diagnosis. By contrast, telemedicine assessments of patients have different limitations depending on the form of communication and context. Some doctors claim that such limitations are so severe as to make the practice unsound.[110] For example, it has been argued that a diagnosis of ear infection requires the possibility of visually inspecting the ear or the throat, that stomach pain requires the doctor to be able to use hand pressure to isolate the problem, and so on.

[110] Andersson et al. (2017).

Exactly what is appropriate to diagnose via video calls is a difficult question, that should be evaluated within the medical profession and assessed by supervisory authorities. Nonetheless, using technology to aid in diagnosis is not exactly new. In the context of telemedicine, there are many technological advancements that facilitate and push the boundaries of what is possible (see also Section 2.4). Since there are established platforms for digital tools, such as for Android and iOS, both professional measuring instruments and cheaper consumer tools are rapidly becoming available. They can be used before or during an actual telemedicine meeting, as well as for follow-up questions or to avoid a physical meeting altogether if the measured values are within acceptable parameter limits. Tools that already exist include those for measuring blood pressure, blood-sugar levels, fever, as well as remote visual inspection of ears and the nose.

As technology evolves, it is possible to connect an increasing number of instruments to a computer or smartphone, which can make it easier for patients to take preventive measures to improve health and perhaps even render subsequent health care visits superfluous. For technology to generate real improvements, however, experience shows that the details of how it is integrated into the workflow and used with patients, crucially matter for the outcome. One study emphasizes lower costs from a shorter hospital stay but also lower mortality.[111]

Video calls, or fully automated services without human contact, can also bring many benefits. Those who are critical of video calls or digital contacts tend to downplay the fact that there are patients who, for various reasons, resist making health care visits despite them being justified. The reasons can be complicated, including obstacles in the form of extended travel, various mobility problems, or family commitments at home. However, there may also be other factors, including, importantly, socially stigmatizing conditions and psychological barriers, that give telemedicine several advantages compared to physical visits, whether for simple or complicated care – see more about this in the section on mental illness below (Box 4).

[111] Willmitch et al. (2012).

Results from research

One paper argues that there is no scientific support for carrying out diagnoses via video calls.[112] A general observation is that it takes time before proper evaluations can be made. For example, there was sharp criticism when e-journals were about to be introduced in Uppsala in 2009 (see section 2.8), but the legislation has since then been updated, and the technology has become broadly accepted.

Notwithstanding claims about the lack of knowledge about telemedicine, we have a more optimistic view of the state of knowledge in this area and the possibility of making diagnoses and conducting treatment without physical meetings. A systematic review published in the well-known Cochrane knowledge database finds *no* evidence of any systematic differences between treatment in telemedicine vs. treatment in physical meetings, for a range of health concerns including diabetes, heart failure, respiratory problems, and mental illness.[113] Particularly concerning mental illness, many studies show positive results (see also Section 4.1 below).[114]

Another criticism of telemedicine is that it generates an increased demand for simple health care in the population, which risks pulling away resources from those who are most sick. On the demand-side effects of telemedicine, there are mixed results. Some studies have found an increased volume of health care visits and increased costs in telemedicine. An extensive American study with 300,000 patients found a volume increase of 88 percent, and that only 12 percent of telemedicine meetings replaced physical primary care visits.[115] In a pilot study in the UK, however, telemedicine led to almost one-fifth of the patients not needing physical care, a result still awaiting peer-review.[116] Another leading US study found several cost advantages from telemedicine.[117]

An analysis calibrated to Swedish condition indicates that telemedicine could reduce costs by about 50 percent compared to physical visits in primary care, which means savings in the order of

[112] Tegelberg et al. (2018).
[113] Flodgren et al. (2015).
[114] Backhaus et al. (2012), Dang et al. (2018), Rees and Maclaine (2015).
[115] Ashwood et al. (2017).
[116] Madan (2014).
[117] Mehrotra et al. (2013a).

magnitude of 1–10 billion SEK (about EUR 0.1–1 billion), depending on the degree to which new demand is created and the extent to which telemedicine can substitute for physical care.[118] Conflicting results from various reports on increased volume indicate that health care and remuneration systems can have a significant impact.

Over-consumption of simple care in telemedicine or "cream-skimming"?

Concerns have been expressed that telemedicine in Sweden encourages over-consumption, for example, by encouraging those with simple complaints to seek medical attention. There is also a related criticism that telemedicine attracts more "healthy" patients, while health care clinics are left with patients with complex or extensive care needs.

Who accesses the care and for what purposes is not easy to determine empirically because of data issues as well as the large degree of decentralization. Each county council is responsible for the digital health care providers that are registered in the region. This means the Jönköping county region, for example, is responsible for supervision of the telemedicine firms *Kry* and *Min Doktor*.

However, we view the criticism of "cream-skimming" that is leveled against telemedicine firms as lacking foundation. In the health care sector, the term "cream-skimming" is usually applied when a health care provider is suspected of selecting patients who may suffer from simple or cheap-to-treat patients and, at the same time, deterring those patients viewed as difficult or expensive. It is, of course, possible that socio-economically strong patients are heavier users of telemedicine than others. The data is especially clear about the elderly being infrequent users of telemedicine compared to all others, even though they typically have the most to gain from avoiding the extra effort that a physical care visit entails. However, this outcome is probably due to a digital exclusion rather than to any physical or economic obstacle. The telemedicine doctors cannot opt out of treating "expensive" patients but, but on the other hand, *Min Doktor* has an e-triage function whereby a person is not put through

[118] Ekman (2017a). For a more complete, but unpublished version in Swedish, see Ekman (2017b).

if a doctor's consultation is not medically warranted. We think this form of e-triage makes eminent sense and indeed is a necessary feature given the greater ease of access provided by telemedicine.

Over-consumption of health care is not something that can be easily measured, and is arguably, at least to some extent, about subjective issues. Welfare services that contain a high degree of government subsidy must, however, be restricted in one way or another; otherwise, the costs will increase without bounds. What is the correct level? It is not an issue that we – or anyone else for that matter – can answer in a meaningful way. In principle, it is ambiguous whether telemedicine leads to higher or lower costs. If a doctor in telemedicine treats a patient with a "real" disorder, the cost is about one-third lower than the cost of a physical care center. By contrast, if more hypochondriacs increase their health care consumption through telemedicine, the costs to society may increase.

There are no simple answers when it comes to our questions about the economic and social consequences of improved accessibility. For example, what is the value of early detection of a disease, something that may become more common when digitalization lowers the threshold for contacting telemedicine doctors? Developing e-triage can help to treat medically motivated disorders while at the same time, it should not be too easy for hypochondriacs to get through. It will be a precarious balancing act to develop e-triage that prevents the hypochondriacs from getting through, but that does not hinder those with real medical needs. A significant issue in this regard concerns the current design of the remuneration system in primary care, which is out-of-touch with technological developments.

Conflict due to the remuneration system for telemedicine

Cost effects from digital health care contacts are influenced by how the existing remuneration system is designed (see Box 3). When a patient contacts a doctor through one of the firms that provide service nationwide, their home county council is charged the cost that remains after the patient-fee, usually about SEK 400–450 (about EUR 40), is deducted. In some county councils, this cost is charged

to their budget, as was done during 2018 in, for example, Stockholm, Uppsala, and Västerbotten (see Figure 3.1). In some county councils, by contrast, this cost is passed on to the health care center where the patient is formally listed, and this is the case in, for example, in Blekinge, Gävleborg, and Halland. In the Region Skåne, the payment follows a variation of these two: telemedicine fees within the region are charged to the patient's own health care center (where they are listed), but not out of county visits.

One motive to charge the cost of a telemedicine visit to the health center where the patient is listed is that the patient should have been treated there, but was not: the health care center should make more effort to maintain their listed patients. However, some arguments go in another direction. One issue, in particular, is that the physical health care centers risk having a composition consisting mainly of expensive patients, a situation that was tenable in the past when the total costs from expensive groups were cross-subsidized by others. When the young and digitally savvy switch to telemedicine, the social contract between generations risks being disrupted from the way the existing remuneration system is conceived. Most patients also have no clue that the primary health care centers receive remuneration via capitation and even less knowledge that some are liable to repayment as a result of the telemedicine visits of their listed patients. Overall, transparency in how remuneration works is weak, competition between the public and private sector is affected by shifting rules, and the environment for long-term planning is correspondingly uncertain. More specifically, the county councils' different handling of the fees to telemedicine firms has created a situation with considerable arbitrariness in how digital health care is implemented.

Figure 3.1 The county council's budget management of fees separated by how they handle telemedicine fees on the central budget or demand repayment from health care center where the patient is listed.

Central budget	Demand repayment
Gotland, Jämtland, Jönköping, Kalmar, Skåne (in part), Stockholm, Sörmland, Uppsala, Västerbotten, Västra Götaland, Örebro och Östergötland	Blekinge, Dalarna, Gävleborg, Halland, Kronoberg, and Västmanland

Source: Own mail contact with county councils. Note: The *Region Norrbotten* as of November 12, 2018 has not yet provided any information.

The remuneration system has created a kind of economic conflict between physical health care centers and telemedicine firms. The fact that the county councils also have such different ways to handle telemedicine creates widely different conditions for health care centers, where location matters quite a lot. If nothing is done, the economic tensions between the regions and the private health care providers are set to increase. We have not formed a view on the direction of change for the remuneration system, but we note that it should be easier to understand and have more transparent pricing. Currently, planning conditions in the short and long run for physical health centers are made unnecessarily complicated, as many do not know what compensation they will obtain from the county councils. The remuneration system is currently being reviewed by the government.[119]

The work of telemedicine physicians is also made more difficult in some parts of Sweden. Health care centers are not allowed to differentiate among patients, but it has emerged that some health care centers obfuscate the work of telemedicine doctors by ignoring their referrals for physical tests.[120] Moreover, this is despite the telemedicine doctor's paying for the service.

[119] The remuneration system is subject to a Governmental Inquiry, Socialdepartementet (Ministry of Social Affairs), S 2017:08, with some supplemental tasks March 1, 2018 (dir: 2018:14).
[120] Däljemar (2018).

Box 3. Remuneration system for digital health care.[121]

The primary remuneration in primary care is via capitation, which is based on the number of patients listed at a particular health care center. By contrast, telemedicine physicians are instead part of a different remuneration system based on so-called out-of-region visits, where the patient's home region pays the region where the telemedicine firms are registered. During 2016–18, most of the out-of-region visits were to Region Jönköping, as the large telemedicine firms *Kry* and *Min Doktor* are registered there. Initially, the out-of-region fee was hefty – at SEK 2,195. It was subsequently reduced in two steps and has since May 2017 been SEK 650 per visit (about EUR 60) of which the patient fee amounts to approximately SEK 200-250. Children under the age of 20 and those older than 85 pay no fee for primary care visits. Nor do those who have reached the high-cost ceiling in health care, which was SEK 1,100 in 2018 over twelve months.

The remuneration of telemedicine creates tensions between the regions as well as some bureaucratic quagmire. The system was constructed at a time when out-of-region visits were few. There are also some peculiar price differences that reflect the choices the regions have made. The price difference is most clearly evident for Region Sörmland, where primary health care is free of charge for the residents and hence so is telemedicine via the firm *doctor.se*, established there on January 1, 2018. A patient resident in Stockholm using the telemedicine firms *Kry* or *Min Doktor* thus typically pays a patient fee of about SEK 250, but SEK 0 (zero) if they instead contact *doktor.se*. This practice has led the Swedish Association of Municipalities and the Regions (SKL) to agree on a recommended minimum fee for digital care, SEK 100, which, however, has not yet been implemented by Sörmland County Council at the time of writing.

[121] Blix and Jeansson (2018).

Supervision and accessibility

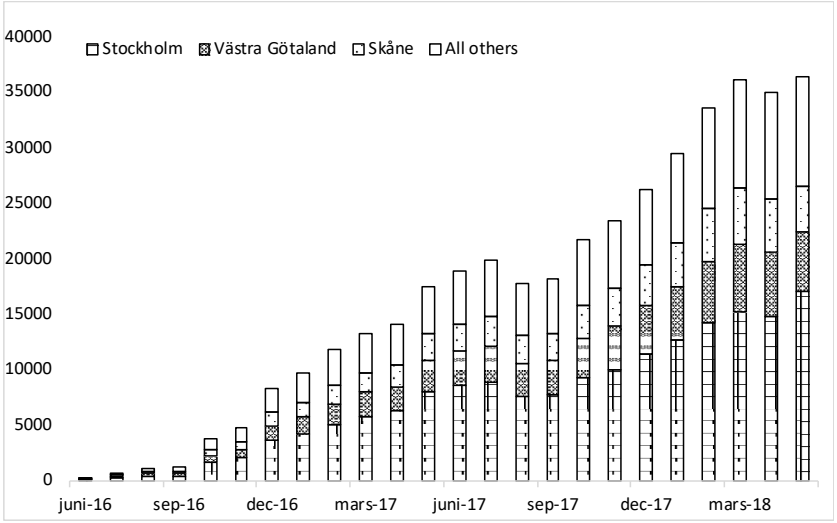
There are also other important questions about digital health care. In Sweden, some telemedicine firms have been criticized for prescribing antibiotics on insufficient grounds in 2016.[122] That criticism has in turn been questioned as being based on shallow investigations.[123] From an outside perspective, it is hard to assess the veracity of the critique or the counter-arguments; international experience points in both directions. A US study finds no difference in the follow-up between patients but a higher tendency to prescribe antibiotics in telemedicine[124], while another, more recent report with some of the same co-authors, finds no systematic differences in antibiotic discharge between physical and digital health care.[125]

After the criticism of antibiotics prescriptions, Jönköping County Council has strengthened routines as well as the supervision of the telemedicine firms registered there. This is to be welcomed. We consider it important that all health care actors – regardless of whether the form of the interaction is digital or physical – are kept to the same high standards. In all care, sometimes mistakes are made, and it is no more or less severe because it happens in a digital context.

An advantage of telemedicine is that the format, as well as the increased accessibility, are given high marks by many patients. In Sweden, the number of telemedicine visits has increased sharply since 2016. Overall, there were approximately 403,000 digital visits during the period June 2016 to May 2018 to Region Jönköping (*Kry*, *Min Doktor*, and *Medicoo*), of which only the first five months in 2018 represent 42 percent of these visits, see Figure 3.2. Although sparsely populated areas have a lot to gain from digital care, telemedicine is mostly a big-city or Stockholm phenomenon.

[122] RJL (2017).
[123] Cederberg (2017).
[124] Mehrotra et al. (2013a).
[125] Schoenfeld et al. (2016).

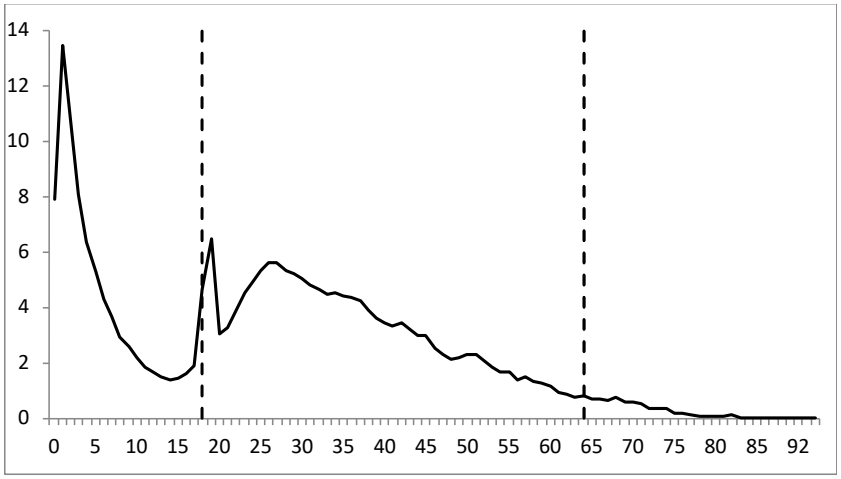
Figure 3.2 Number of digital visits via region Jönköping County Council, June 2016 – May 2018.



Source: Unpublished figures from Region Jönköping County Council.

Concerning age distribution for those who use telemedicine, the young dominate it, and the curve is much like an "L" (see Figure 3.3). Children aged 0–4 account for almost 20 percent of all visits. The fact that the number of visits increases for older teenagers only to suddenly decrease and then reverse, followed by a gradual decline, can partly be explained by the fact that primary health care for children is free of charge until the age of 20. It is worth noting that older people, despite more significant health care needs and free primary care from 85+, exhibit substantially fewer telemedicine visits. This development is in line with the picture of a digital exclusion for the elderly, which is discussed in other parts of the report. Once the elderly increase in digital maturity, their telemedicine visits are likely to increase. It is reasonable to assume that the "L"-curve will increasingly be transformed into a "U"-curve given today's remunerations system.

Figure 3.3 Number of digital visits to the Jönköping Region by age, June 2016 – Dec 2017.



Source: Unpublished figures from Jönköping County Council.

There is research that shows cost-savings from telemedicine stemming from health care needs being addressed in a more timely fashion, which reduces the risk of acute care visits at a later stage.[126] In Sweden, the experience from Region Västerbotten is that telemedicine provides benefits for patients, doctors, and society. These benefits apply to several different forms of health care, including rheumatology, primary care visits, cardiac ultrasound with the support of robotics, teledermatology, and support for children with suspected heart defects.[127] The region also finds that travel has decreased and estimates that 288 digital care visits have been able to replace 164 physical trips, thereby also reducing the need for accommodation. If the value of the patients' own time is added, the savings would be even more significant, especially for those who need to be absent from their jobs.

Finally, in Sweden for many years, experience has been gained from a rural medical center in Storuman, where one single doctor has an on-call area that is as large as three large regions put together (Skåne, Halland, and Blekinge). The clinic has several examination-rooms with different types of digital tools for making a diagnosis remotely and sometimes also initiating treatment.[128] In Sunderby's

[126] Darkins et al. (2015), Veroff et al. (2013).
[127] Molén and Holmner (2016).
[128] Lövtrup (2013).

hospital outside Luleå (in the north of Sweden) there is a doctor who conducts hearing examinations on patients who are far away and in other places, such as in Kiruna and Gällivare.[129]

Internationally, there is also evidence for reduced travel costs and, in a leading US study, with just over 11,000 patients, their travel time decreased by an average of 245 minutes per patient.[130] Another US study with 40,000 patients found strong evidence for cost savings.[131] In Greece, where the geography of many remote islands creates some similarities with rural Sweden, there is strong evidence that telemedicine provides significant savings and there are also indications of improvements in social dimensions.[132]

3.2 Communication and SMS reminders

Few things have such a firm grip in health care as established ways of communication. Using faxes and sending regular mail by post has been prevalent in health care but is becoming increasingly anachronistic when there are new digital tools that are faster, cheaper, and easier. It is clear that patients want to be able to communicate via e-mail and mobile communications and to make online bookings for visits or chats, but there is notable resistance from within parts of the medical profession.[133] It is possible to understand the concern of the medical doctors because e-mail could increase the workload without resources necessarily going to patients with more dire medical needs.

In the US, there are studies for the period 2005–10 that indicate that almost everyone reads their electronic messages; the exception is socio-economically weak groups, who are also worse at using web portals.[134] This problem should, to a certain extent, decline as the general digital maturity increases, and smartphones become ubiquitous. It is worth recalling that the first iPhone was launched in 2007, and the popularity of various smartphones has significantly grown since then in both developed and developing countries. For example, there are signs that refugees from conflict areas in the

[129] Carpman (2018).
[130] Dullet et al. (2017).
[131] Courneya et al. (2013).
[132] Kouskoukis and Botsaris (2016).
[133] Lee (2016a).
[134] Crotty et al. (2015), Irizarry et al. (2015).

Middle East and Africa use smartphones to communicate with each other and exchange different tips on routes and how to seek asylum.

There are no reliable statistics on how common it is to not have a smartphone for economic reasons. In Sweden, however, the so-called internet penetration ratio is unusually high compared to many countries and the lowest level of education is also quite high. On the other hand, there are signs that the elderly in Sweden find it hard to use digital communication, and it is, therefore, essential that there are various forms of support that reduce the risk of growing digital exclusion in care.[135] In Sweden, even for weak socio-economic groups, access to electronic communication is widely available, and the results from the US are not applicable.

The simplest form of electronic communication is SMS reminders, for example, for booked health care visits. In the discussion about AI and other sophisticated technology, it is important to recall that small – and simple technical solutions – can sometimes be quite substantial. Fewer no-show health care visits bring many advantages. The doctors' time is better used if patients attend their appointments, and patients who unknowingly have acute care needs can be treated in a more timely way. There is one leading study that warns of limited time gains.[136] However, the research overall speaks in unison about time and cost savings from SMS-reminders.[137] In the Västra Götaland Region, 150,000 patients were absent from booked visits in 2016, which resulted in an unnecessary cost of over SEK 400 million (about EUR 37 million).[138] Although there are simple savings, not all regions use this technology.

E-portals are also used to communicate with patients. An extensive review found that 40 percent of studies report positive results in terms of improved medication, follow-up, and health care consultations, and that patient satisfaction is improved.[139]

[135] Viscovi et al. (2017).
[136] Free et al. (2013).
[137] Downing et al. (2013), Gordon et al. (2015), Gurol-Urganzi et al. (2013), Guy et al. (2012), Hasvold et al. (2011), Junod Perron et al. (2013).
[138] Holmqvist and Nyman (2017).
[139] Kruse et al. (2015).

4 Complicated care

In this section, we describe the effects of digitalization on complicated care. The various sub-sections discuss mental illnesses, chronic diseases and care of the elderly. The results of the research on digitalization and health care are summarized in Table 4.1 (divided into two pages), which also includes results from simple care in order to present a useful overview. It is not self-evident how the different parts of the table should be defined, and our headings aim at, as far as possible, reflect the various sub-sections in our report. In addition to a summary of each area, there is also a note pointing to the section in which the results are discussed.

In Table 4.2, we use the same organizational principle but, instead, report results from media, companies and web pages. In other words, Table 4.1 summarizes the evidence of the effects of digitalization on health care while Table 4.2 shows an approximate direction for what is already – or may soon become – possible.

Table 4.1 Summary of the research on health care and digitalization 2010–18.

Subject (location)	Summary
Digital tools and e-journals (2.3 and 2.9)	Reduces pain intensity, facilitates self-care and facilitates support from social networks (**Bender et al. 2011**). Electronic ordering of medicine is cost-effective (**Vermeulen et al. 2015**). Kaiser Permanente implemented a comprehensive system for e-health that has grown from 4.1 million in 2008 to 10.5 million in 2013 (Pearl et al. 2014). No cost savings without organizational changes (**Adler-Milstein et al. 2013**) and mixed results when workflows change (**Nguyen et al. 2014**). Positive results but not clear that patients have access to e-journals (**Davis Giardina et al. 2014**). Increased patient satisfaction but concern among doctors for extra work (de Lusignan et al. 2014). 80% more satisfied patients and some increase in doctor's time but no reported injuries/leaking of sensitive information (**Mold et al. 2015**). Electronic data reduced the need for diagnostic tests and improved compliance with emergency care guidelines, but did not result in any general cost savings (**Bailey et al. 2013**). Digital technology improves medication, reduces errors and speeds up processing (**Ker et al. 2014**). Good experience with patient portal in Canada in terms of communication between doctors and patients
e-triage and AI diagnosis (2.8 and 4.2)	Smartphone app better diagnostic ability compared to a physical examination for some disorders related to the arteries (**Di Santo et al. 2018**). Neural networks such as CNN have been able to diagnose skin- and lung cancer faster and in many cases better than specialist doctors (Esteva et al. 2017, Haenssle et al. 2018 and Wang et al. 2017). Machine learning works well to classify CT and MRI images to detect cancer, and reduce costs (Nguyen and Patrick 2014). 20% lower costs and statistically significant (Warren et al. 2017). E-triage of eye problems gives better sorting of patients and reduces median waiting time from 14 to 4 weeks (Khan et al. 2015). AI as good or better than ophthalmologists to diagnose about fifty eye diseases (de Fauw et al. 2018). e-triage results in better communication in rheumatology (**Scheibe et al. 2015**). e-triage worked well and was appreciated by patients for control and follow-up of sexually transmitted diseases (Jones et al. 2010). AI diagnosis from spoken language gives 72% chance to assess incipient psychosis (**Corcoran et al. 2018**).
Communication and SMS reminders (3.2)	Almost all patients read their electronic messages but worse among socio-economically weak groups (Crotty et al. 2015, **Irizarry et al. 2015**). Patients have a great interest in communicating with e-mail, but not doctors (**Lee et al. 2016a**). Reduced missed visits and win-win for doctors and patients with e-reservations (Paré et al. 2014). Improved medication, follow-up, and care visit as well as patient satisfaction better but overall weak results in median terms (Kruse et al. 2015). Only limited time gains and some deterioration in diagnostic ability (Free et al. 2013) but several other studies have considerable coherence on reducing absenteeism during booked visits (Downing et al. 2013; Gordon et al. 2015; **Gurol-Urganzi m. fl. 2013**; **Guy et al. 2012**; Hasvold and Wootton 2011; Junod Perron et al. 2013).

Note: Studies in boldface letters indicate studies published in highly ranked scientific journals. For a description of each study, see Table A in the appendix. The first column lists the section in parentheses, where the topic is addressed in the report. The table is continued on the next page.

4.1 Mental illnesses

Mental ill health is a widespread problem with consequences in several dimensions. One estimate is that about one-fifth of the populations in OECD countries suffer from some form of mild-to-moderate mental ill health.[140] Also, it is an area of health care that receives fewer resources than others, particularly in developing countries.[141] However, the World Health Organization (WHO) emphasizes that treatments are substandard even in many European countries.[142] Patients who do not receive treatment suffer unnecessary and have more difficulties being part of society and the labor market. Also, relatives are affected to varying degrees. Moreover,

[140] OECD (2014, 2015).
[141] WHO (2018a).
[142] WHO (2018b).

mental illnesses can be a factor that leads to suicide or self-destructive behavior.

An extensive review of the state of knowledge highlights the importance of early intervention as a decisive factor in alleviating detrimental effects.[143] Notably, early onset of mental illness can adversely affect the quality of educational outcomes and thus have far-reaching consequences for the entire working life as well as impairing social life. Mental ill health later in life risks leading to poorly paid jobs and insecure employment. One estimate for Sweden is that people with mild-to-moderate mental illness have about ten percentage points lower employment rate and nearly twenty percentage points lower labor productivity.[144]

[143] OECD (2015).
[144] OECD (2015, p. 31).

Table 4.1 Summary (cont.)

Subject (location)	Summary
Cronic diseases: diabetes, cardio, cancer etc. (4.2)	Reduced costs through better follow-up, medication and patient satisfaction (Javitt et al. 2014, **Byrne et al. 2010, Inglis et al. 2015**). Better glucose and blood pressure control for patients with type II diabetes (**O'Connor et al. 2011**). Distance care for chronic diseases such as diabetes and heart failure has reduced the need for emergency visits in Canada and improved quality of life (Canada Health Infoway 2014). Remote monitoring of blood pressure was estimated by patients (Cottrell et al. 2012), but compliance with guidelines deteriorated over time (**Cottrell et al. 2015**). Fewer care visits for chronically ill people give higher quality of life and cost savings (**Cingi et al. 2015**, Paré et al. 2013). Cost savings by requiring fewer patients to seek emergency care (**Frisse et al. 2012**). The Nightscout project in the USA provides increased opportunities for own diabetes care via free open source code (Lee et al. 2016b).
Mental health (4.1)	Online physicians and e-tools and provide significant cost savings (Hilty et al. 2014, NMHC 2014). Telemedicine is estimated by patients and the outcomes are similar to regular meetings (Backhaus et al. 2012, Dang et al. 2018, Rees and Maclaine 2015). Apps and digital support significantly reduce depression, stress and medication (**Donker et al. 2013**, Forchuk et al. 2015). Electronic communication is no worse than direct calls except for patients with a high need for care and points to the importance of targeted efforts for this group (**Hammond et al. 2012**). e-treatments established for depression, panic and social phobia and are cost-effective (**Hedman et al. 2013**, Proudfoot et al. 2013). Smartphones improve health insight and facilitate treatment in the first line (**Kauer et al. 2012**) and are at least as good as regular methods (van der Krieke et al. 2014). Creates difficulties in documentation in the absence of standardization (**Kobus et al. 2013**). E-therapy effective in controlled forms but unclear if applicable more generally (**Newby et al. 2013**). Works well when controlled by a doctor (**Olthuis et al. 2016**). Improvements and less time spent by doctors and no reported adverse effects (Stott et al. 2013). Computer animated Avatar in conversation therapy can lead to relieving schizophrenia (Leff et al. 2012). Digital tools significantly reduced symptoms and concerns after 1-2 months (Yu et al. 2018).
Telemedicine (3.1)	Cost savings 4-5% through distance treatment from fewer visits to healthcare and better control of medication (Darkins et al. 2015, **Veroff et al. 2013**), as well as reduced travel costs (**Dullet et al. 2017**), reduced hospital stays by 25% (Godleski etc. in 2012) and in sparsely populated areas both in terms of reduced costs and a stronger social dimension (**Kouskoukis and Botsaris 2016**). Savings SEK 1–10 billion possible (**Ekman 2017a**). Missing scientific support for video diagnoses (Tegelberg et al. 2018). No difference treatment compared to regular healthcare meetings for diabetes, heart disease, respiratory problems or mental illness (**Flodgren et al. 2015**). More difference between caregivers than if the form is video call or ordinary physical care meeting (**Schoenfeld et al. 2018**). E-health in the form of home care provided higher productivity through better documentation and follow-up (Sockolow et al. 2014). Improved accessibility but increased costs per patient (**Ashwood et al. 2017**). Inferior outcome for ordering diagnostic tests (Uscher-Pines et al. 2016). Cost benefits of e-health but tend to print more antiobiotics, using mainly younger and no relation to income level (**Mehrotra et al. 2013a** and b). Significant artifacts but unclear gains (**Kumar et al. 2013**). Online physicians improve for patients and reduce costs by $ 88 per patient based on analysis of about 40,000 treatments (Courneya et al. 2013). For patients with high blood pressure, smartphone use only led to limited improvements (**Morawski et al. 2018**) but Saxon (2018) criticizes the methodology for missing important medical feedback.
Intensive care and learning (2.5 och 4.2)	Collected electronic information improves flow and reduces hospital time and provides significant time savings (Clark et al. 2014). Reduced mortality through better adherence to guidelines and better use of data (**Lilly et al. 2014**). Reduced health care, hospitalization and relative mortality (**Willmitch et al. 2012**). Appreciated by surgeons both in design and as distance education (Augestad et al. 2012).
Elderly care (4.3)	Increased participation and user satisfaction through integrated elder care in PRISMA (Stewart et al. 2013). Reduces costs for studies on impaired vision through less need for scheduling but does not apply to elderly people in low risk category (**Wittenborn et al. 2017**). Telemedicine effective support for the elderly by reducing hospitalization (Hwang et al. 2014).

Although many countries are investing considerable resources in countering mental illness, knowledge in this area remains inadequate. In Australia, this has been highlighted in a public inquiry that shows that about AUD 10 billion is spent each year on mental illnesses, but with somewhat unclear effect.[145] The study estimates the direct and indirect socio-economic costs to AUD 28.6 billion per year. Approximately 20 percent of the population in the ages 16–85 years is considered to have some form of mild mental illness. Moreover, there are other dire effects of mental ill health, notably a lower likelihood of getting a job and a higher risk of unemployment, valued at an estimated cost of AUD 12 billion.

[145] NMHC (2014).

In total, the study estimated the costs of mental illnesses to be approximately AUD 40 billion, or 2 percent of GDP per year. It is reasonable to assume that the incidence of mental illnesses in other countries that have not been affected by war or poverty is similar to that of Australia. An overview of the OECD for all rich countries shows even higher costs, about 4 percent of GDP and about 3.5 percent of GDP for Sweden.[146]

Mental illnesses are often complicated and many times require several measures and a coherent vision, not only from the care system, but also from authorities in the work and social insurance systems. Below we discuss experiences that show that video calls are often as good or better, except for those patients who suffer from severe or extensive mental illnesses. In simple terms, video calls can lower the threshold to get in touch with health care and have good potential to facilitate the treatment of mental illnesses.[147] Also, the risk of stigmatization, which is all to common issue around mental illness, is lower (see box 4).

Box 4. Examples of situations when patients prefer robot- or video calls.

In the mainstream media, telemedicine discussions have focused mostly on simple care, but many of the benefits also apply to complicated care such as mental illnesses.

Mental ill health is a taboo area, despite the reality that, according to studies, up to one-fifth of the population in OECD countries suffer from mild to moderate mental illness.[148] Mental illnesses impose different obstacles in social contexts, and the risk of discrimination in the labor market, even when treatment makes symptoms manageable or under control. Another issue is that those with mental health issues may hesitate to reach out for help. The risk of embarrassment from being recognized while seeking help for mental illness can be an insurmountable obstacle. This problem applies not only to those with mild symptoms, but also to the young and other groups with mental health issues. The fact that there are simple and less stigmatizing ways to get help

[146] OECD (2014, p. 29).
[147] NMHC (2014, p. 192).
[148] OECD (2015).

can make a big difference. Those who get timely help may also be at a lower risk of harm or suicide.

Sexually transmitted diseases are another area where taboo and awkwardness can make it difficult for patients, especially the young, to seek care.

Those who have been exposed to mental or physical trauma may have a high threshold for pain before they seek help, even when their need is significant. In the US, there are war veterans who suffer from post-traumatic stress disorder (PTSD) after experiences in conflict areas, such as Afghanistan, Iraq, and Vietnam.

In these examples, digital or telemedicine contact can make all the difference between abstaining from treatment and seeking help. A telemedicine contact also does not have to be with a doctor or nurse. Some researchers have developed software that can converse or chat with patients 24/7. This technology, which previously seemed like science fiction, has now come to the point where voice recognition and language processing have vastly improved. Talking to a robot or an avatar may be more comfortable for some than talking to a real doctor, because the latter may be unable to refrain from imputing (unintentional) negative values into tone or dialogue of their response. Human contact is often a strength, but not always. Moreover, if an avatar proves insufficient, the health care staff can take over the conversation. Avatars can also give support and advice 24/7 at low cost, something that no human can handle. The cardiologist Leslie Saxon at the Center for Body Computing, for example, has programmed an avatar that provides advice on heart disease. It has been given her voice and personality.[149]

All in all, there are situations where stigma can present enough of an obstacle that patients choose to abstain from care. There are also long journeys that make doctor visits more or less impractical apart from life-threatening emergencies, for example, in regions such as Alaska.[150] Here, a conversation or chat with an avatar or a telemedicine doctor can provide a way to receive care for conditions that would otherwise remain untreated. Moreover, when it comes to conversations with an avatar, the cost is low,

[149] Olsson Jeffrey (2017).
[150] Maron (2014).

which is especially important in countries where access to health care is limited for those with low income or where taxpayers account for a large part of the cost.

Results in the research literature

There are few areas of research concerning digitalization and health care where the data is as extensive as it is for mental illnesses. A summary of these research results is presented in Table 4.1.

Not all results can be generalized, but reviews of the literature show that telemedicine is effective for treating mental illness and that the form is appreciated by patients.[151] In telemedicine, one lesson is that it is essential to standardize documentation.[152] Apart from patients with extensive mental illness, the research shows that telemedicine and electronic communication are as useful as physical meetings.[153] This result holds for many forms of mental ill health, including depression, anxiety, and social phobia.[154] A comprehensive literature review shows particularly good results when doctors lead e-treatments and discussion groups.[155]

Telemedicine calls can be combined to achieve more impact through apps and various other forms of digital support.[156] A leading study shows that telemedicine leads to less depression, anxiety and medication.[157] There is also clear evidence that the use of apps facilitates treatment in "first line-care" and strengthens patients' understanding of their health situation.[158]

[151] Dang et al. (2018), Newby et al. (2013).
[152] Kobus et al. (2013).
[153] Backhaus et al. (2012), Hammond et al. (2012), Hedman et al. (2012), Proudfoot et al. (2013), Hilty et al. (2013), Rees and Maclaine (2015).
[154] Van der Krieke et al. (2014), Hedman et al. (2013), Proudfoot et al. (2013).
[155] Olthuis et al. (2016).
[156] Forchuk et al. (2015).
[157] Donker et al. (2013).
[158] Kauer et al. (2012).

Table 4.2 Results from news media and web pages.

Subject (location)	Summary
Digital tools and e-journals (2.3 and 2.9)	By systematically applying digitalisation in 14 areas in the healthcare sector, it is possible to save SEK 145-180 billion up to 2025 (McKinsey 2016). Cohesive e-health in Estonia with portal and e-journals. The GoodSAM app available in London not only contacts the alarm center but automatically checks if there are qualified healthcare professionals nearby. Can save crucial seconds for eg heart attack. Mobile Dishes is an app that does the same in Germany. Distance examination of eyes, heart and ears possible via digital stethoscope, opthalmoscope and otoscope. Digital assistants can help the blind and the deaf to communicate and interact with the outside world, but a difficulty turned out to be the importance of digital prerequisites for asking 'right' questions (Bogost 2018).
e-triage and AI diagnosis (2.8 and 4.2)	IBM Watson has several e-Health applications, including oncology (www.ibm.com/watson/health). IBM Watson hyped and no better than doctors (Gorski 2017) and that the opportunities with AI are grossly overestimated (Davies and Marcus 2016). Collaboration between Google DeepMind and Moorfield's Eye Hospital to develop AI programs to identify eye diseases from digital images, which can save hours of work and also be applied in other areas (De Fauw 2017). Babylon uses AI technology to make diagnoses (Ram 2018) but has also been criticized by doctors for missing potentially serious diseases (Ram and Neville 2018). Ava is a service with primary care physicians (i-gp.uk) conducting e-triage with about fifty questions and updating questions about guidelines being changed and providing contact with doctors. Virtual consultations Babylon Health. UK: Ada personal health doctor (https://ada.com). USA: Doctor on Demand, Live Health Online, Teledoc, Amwell.
Communication and SMS reminders (3.2)	In the Västra Götaland region, 150,000 patients were absent from booked visits, which resulted in a cost of over SEK 400 million, Holmqvist and Nyman (2017).

There is also evidence that telemedicine leads to direct time and cost savings.[159] A leading study shows that doctors save time and that the effects of treatments are positive.[160] In Australia, there have been good experiences of digital health care, including the benefits of online chats for mental illnesses.[161] For example, one evaluation of digital support for patients through a chat (*Lifeline Online Crisis Support Chat*) shows that the same quality-adjusted life years can be achieved, but with 10–20 percent lower costs compared to medication or psychological support respectively.[162] In the US, another evaluation shows that the hospital stays for 98,000 US veterans was reduced by 25 percent when digital care and video calls were introduced.[163] It is also possible for a doctor to start many chats simultaneously over several days because not all patients are in a hurry.[164]

Beyond video calls and apps, even more advanced digital technology has been developed. Some studies are approaching methods that would have been science fiction just a decade ago. For example, research shows that conversation-therapy that is supported by computer animated avatars and augmented reality can alleviate schizophrenia.[165] When patients suffering from imaginary persecu-

[159] Stott et al. (2013).
[160] Hedman et al. (2013).
[161] NMHC (2014), Rees and Maclaine (2015).
[162] NMHC (2014, p. 192).
[163] Godleski et al. (2012).
[164] There is evidence that some patients in Capio have a chat running for several days.
[165] Leff et al. (2012).

tion converse with an avatar, their experience can be gradually redirected from threatening to supportive.

Table 4.2 News media and web pages (cont.).

Subject (location)	Summary
Cronic diseases: diabetes, cardio, cancer etc. (4.2)	Monitoring and monitoring of the heart, www.coalalife.com. Glucose results directly in smartphone (librelink.com). App GlucoSuccess helps patients with type II patients in the United States. Type I diabetes care new model for type I diabetes (visitadialog.se). Modifies open source code to measure blood sugar in real time and send information to smartphone, Omer (2016) and Lee et al. (2016b). Viz.ai can automate the detection of blood clots by brain x-ray analysis much faster than doctors and Kheiron Medical Technologies has improved breast cancer discovery, the Economist (2018). AI platform that helps patients take their medication saves USD20-30 billion through better adherence to protocols (AIcure.com) and diagnosis quality for heart disease, http://www.ultromics.com. Avatars can help those suffering from paralysis to increase their ability to move through virtual visualization (Stuart 2018). Aira is a company focused on helping the blind through augmented reality; a connected healthcare provider can see or hear the surroundings in real time and support in everyday management, such as. to shop in a store, Aira.io and Donahue (2017). For deaf people there is support to learn sign language and work to automate translation of spoken language into sign language., Latlab.ist.rit.edu.
Mental health (4.1)	Machine learning has been used to interpret images of the brain, and with the help of biomarkers, it has been possible to distinguish successful treatments from those who work worse: a form of precision psychiatry that has been applied to patients with bipolar symptoms, social anxiety or depression. However, the cost of the technology is still an obstacle Nesta (2017a). Machine learning is also used to predict the risk of mental illness, such as PTSD, by analyzing user deaths from a smartphone, such as how the finger sweeps and presses the screen. The results can be compared with a large database, Nesta (2017a) and mindstronghealth.com. Virtually reality (VR) begins to be used in therapy to deepen in depth and relive theatrical events or horrifying situations for the treatment of PTSD, schizophrenia or phobias, Nesta (2017b). Trying with automated avatars is trying to bypass the difficulty of scaling up virtual treatments with Avatars, http://www.nowican.com. IBM has developed AI practices that assess the risk of psychosis and schizophrenia based on the spoken language, https://futurism.com/ibm-psychosis-predicting-ai-speech/. The company www.limbix.com has begun to launch VR also to treat various forms of abuse, such as drugs or alcohol, where the patient can get support from healthcare professionals to cope with various situations that
Telemedicine (3.1)	The sparsely populated medical center in Storuman uses video calls and other technology to communicate with patients and to offer full-time physicians or nursing visits, Lövtrup (2013). The concept is being developed in eight other places in Sweden with rooms equipped with digital measuring equipment for eg. blood test, listen to the heart and ear & throat, Åsgård (2018). E-doctor via smartphones in Sweden: Get and My Doctor. The self-dialogue pavilion at Ryhov in Jönköping offers a self-dialysis that saves time and gives power to patients (Koivisto 2017a). Regions with low population density and long travel routes, such
Intensive care and learning (2.5 och 4.2)	Orbeye Robot for $ 400,000 creates 3-D images for neurosurgeons that facilitate surgery and save time. In addition, educational opportunities are strengthened by others being able to see what the church does (Grady; https // medical.olympusamerica.com). Miniature robot that can deliver medicine inside the body and avoid surgical procedures (Hu 2018). The App Emerge in Germany enables you to train healthcare professionals with realistic events during time pressures, http://patientzero-games.com. The Da Vinci robot system is used in many hospitals, https://www.intuitivesurgical.com.
Elderly care (4.3)	"Giraffe" in Västerås for support to the elderly. Five-thousand-year-olds in Japan are testing robots in Japan, including the robot "Pepper" that leads the singing activities, the Economist (2017). Elderly people who play a specially developed computer game have improved their simultaneous capacity and thus dampen dementia, an effect that remains 6 months after the game https://neuroscape.ucsf.edu. Electronic EMG model can be used to predict and detect when someone falls, Ha (2016). The EU finances several projects with robots that help the elderly with exercise and everyday affairs, for example: ict.acanto.eu, www.robot-era.eu/robotera/, www.growmeuup.eu.

Results from news media and web pages

Table 4.2 shows results from studies that have not been peer reviewed, but which appear promising. The Region Värmland has developed an app to support those with mental ill health (*HurMårDu.nu*) to reduce the threshold to ask for help. Health care professionals have also developed virtual reality, VR, and avatars to treat experiences from traumatic events or environments, such as

PTSD and phobias.[166] However, the technology of avatars is expensive. To circumvent the high cost, there are attempts to scale up virtual treatments with automated avatars.[167] Computer games have also shown successful results. The elderly who play a specially developed computer game, for example, have improved their mental capacity and thus dampened the effect of dementia. Improvements lasted six months after the game was played.[168] There are also attempts to reduce the risk of relapse into alcohol or drug abuse through avatars and 3D technology. This works by health care professionals creating a virtual situation that will enable the patient to better understand their "triggers", i.e., situations when the risk of recurrence increases.[169]

In hospital-based care, digital tools have also created new opportunities. Machine algorithms have been used to interpret scanned images of the brain, and through biomarkers, it has been possible to investigate what distinguishes successful therapies in mental ill health from those that fail.[170] This form of precision psychiatry has been applied to patients with bipolar disorder, social anxiety, and depression, although the high cost of the technologies is still an obstacle. Machine learning has begun to be used to predict mental disorders such as PTSD, by gathering continuously generated smartphone data, such as the timing of motion patterns, and comparing results with an extensive database.[171]

4.2 Chronic diseases

Patients with chronic diseases often have extensive contact with care providers and also account for a large part of total health care costs. For Region Stockholm, a survey shows that 10 percent of the population accounted for 80 percent of the costs in 2009.[172] An assessment of the country as a whole showed that just under half of the population represented about 80 percent of total health care

[166] Nesta (2017b).
[167] http://www.nowican.com.
[168] https://neuroscape.ucsf.edu.
[169] Kuchler (2018).
[170] Nesta (2017a).
[171] Nesta (2017a), mindstronghealth.com.
[172] SOU (2016).

costs in 2011. Put differently, patients with chronic disease get 4–6 times as much care as other patients.[173]

Digital tools that facilitate care for these patients can thus create great benefit and improve quality of life. However, improvements are not automatic, and a study on intensive care through telemedicine pointed to substantial initial investment costs and uncertain cost savings.[174] In order to have impact over time, judicious reforms and organizational changes throughout the entire health care system are necessary. If, for example, those with chronic conditions can avoid hospital visits and instead, through digital tools, regularly measure their state of health (instead of guessing or being anxious), this improves their quality of life as well as reduces the pressure on the health care system. Moreover, many people put great value on having more control of their health and being less dependent on physical meetings and time-consuming health care visits. As digital tools are increasingly manufactured for consumer markets, the price gradually drops, and it becomes feasible to have good follow-up at a low cost. This also creates the conditions for patient-generated data to be gathered, leading to new research and improved knowledge. With digital consumer tools, it should be possible to reach more patients and thereby gain a better knowledge of medical differences in treatments for different sexes, age groups, and ethnic origins.

Results in the research literature

Digital care for patients with chronic diseases takes place in several different ways, ranging from opportunities to measure their health status to telemedicine calls with doctors or health care professionals. Here Canada provides an interesting comparison to Sweden, because it is similarly large, sparsely populated in some parts, and has a tax-funded health care system. The Canada Health Infoway project has increased in scope every year and has gathered many different results and insights on digital care.[175]

Based on the experience of some 20 remote monitoring programs with 5,000 patients, digital health care in Canada has significantly

[173] Vårdanalys (2014a).
[174] Kumar et al. (2013).
[175] Canada Health Infoway (2014).

reduced the need for emergency care. The quality of life for patients has also improved. Telemedicine monitoring has also been successful for patients with several chronic diseases, including those with heart conditions and diabetes. One lesson is that doctors should be involved in developing the services in order for the latter to be able to achieve economies of scale, which is important for achieving cost savings in sparsely populated areas. One of the studies from Canada, which, however, is based on a small selection of patients, shows that digital care leads to greatly reduced physical visits and shorter health care outcomes and significantly lower costs.[176]

The private health care provider Kaiser Permanente in the United States has had good experience with integrating digital care for chronically ill patients with physical care. Their overall system of digital care has grown from about 4.1 million patients in 2008 to approximately 10.5 million patients in 2013.[177] The development of their system has required large investments, and there have been several obstacles along the way. Their experience show how important it is to gain acceptance from doctors and to review the remunerations systems that guides compensation for the health care performed.

There are extensive studies on the effects of digital care for chronically ill patients, especially when it comes to diabetes and heart disease. Overall, there is good evidence of reduced costs and higher patient satisfaction from digital follow-up and management of medications.[178] Leading studies show that telemedicine for chronic diseases has meant fewer physical visits, fewer emergency visits, and increased quality of life for patients with diabetes and heart conditions.[179] A comprehensive study of American war veterans over seven years found substantial savings.[180] Concerning patients with type 2 diabetes, some results show that the control of glucose values has improved considerably and reduced costs by about 20 percent in diabetes care.[181] Overall, it is reported that patients are more satisfied with digital care.

[176] Paré et al. (2014).
[177] Pearl (2014).
[178] Javitt (2014), Byrne et al. (2010), Inglis et al. (2015).
[179] Cingi et al. (2015), Frisse et al. (2012).
[180] Byrne et al. (2010).
[181] O'Connor et al. (2011), Warren et al. (2017).

There are also results that indicate that digital solutions do not always lead to better results. A study in the UK showed initial positive results for monitoring blood pressure, but a follow-up study showed that patients' compliance decreased with time.[182] Indications of reduced compliance are also found in a US study showing that patients using apps show only a marginal improvement in the use of medicine and no difference in systolic blood pressure.[183] The study has, however, been criticized for omitting interaction and follow-up between doctor and patient.[184]

Results from news media and web pages

We discussed above how digitalization provides patients with opportunities to take better control of their health; this is especially true when it comes to patients with chronic disorders. The concept of "lead patients" is sometimes used to describe those who have excellent knowledge of their own need for care and who, through new tools and e-communication, can increase their quality of life and better calibrate their state of health. Lead patients can be, for example, those with diabetes, heart conditions, or neurological disorders. Our reading of this development is that there are many individual positive experiences and different forms of knowledge that have been built up, but we have not come into contact with systematic research that evaluates the phenomenon. This may in part be because of a methodological challenge to studying lead patients: by definition, they have chosen to invest their own time and resources into improving their health. It is therefore difficult to develop experiments that can evaluate the results lead patients are achieving, compared to a control group that is not active.

Additionally, measuring savings from digitalized self-care that have been established in the research so far can, in this context, be too narrow, in part because research tends to be backward looking and it takes time before new methods and technologies are evaluated.

In diabetes, it is particularly evident how both patients and companies are investing in developing new ways of measuring and

[182] Cottrell et al. (2012, 2015).
[183] Morawski et al. (2018).
[184] Saxon (2018).

following fundamental values. The app *GlucoSuccess*, for example, was developed to help patients with type 2 diabetes, and it is available in Apple's Research Kit.[185]

The *FreeStyleLibre* service can deliver glucose data directly to users' smartphones in Sweden in Sweden. Since there are many diabetes medicines for doctors to keep track of, patients' data can increase the knowledge of which choices are best suited to them, especially as there may be differences between gender and ethnic groups. Using big data has the potential to improve the accuracy of medicine beyond restrictive assumptions of "normal patients" and averages.

Patients and relatives with knowledge in programming have used open source software to create software themselves for better follow-up of diabetes, such as the Nightscout project in the US and "health hackers" in the UK.[186] For patients who want to monitor their heart with digital aids, the commercial service *Coala* is available in Sweden to deliver data to a smartphone.[187]

AI technology is expanding into different areas and other smart solutions are entering health care. One example is an app that helps patients to take the right medications, which the company itself estimates could lead to cost savings of USD 20–30 billion through better compliance with drug prescriptions.[188] Some results point to improved routines and reduced medication errors, which can entail substantial savings, up to 15 percent of the costs for hospital care in the OECD countries as a whole.[189] A study from the US based on 33,000 patients showed that patients who have difficulty following instructions cost about 8 percent more during the first year and 21 percent more the year after.[190]

Above we discussed how avatars have been developed for the treatment of mental illness, but there are also other uses for that technology. At the University of Southern California's Neural Plasticity and Neurorehabilitation laboratory, various forms of virtual reality (or augmented reality) are developed with the Oculus

[185] https://www.freestylelibre.se.
[186] Omer (2016), Lee et al. (2016b).
[187] https://www.coalalife.com.
[188] https://aicure.com.
[189] Slawomirski et al. (2017).
[190] Hibbard et al. (2013).

RIFT platform to help, for example, patients with paralysis to improve their mobility.[191] Through computer simulation, the aim is to make the body remember movement patterns and stimulate activity. So far, there is considerable variation in the results of treatment of stroke patients with these methods and some of the research therefore examines which factors that give the best results.[192]

4.3 Support for the elderly

Health care is often discussed separately from elderly care. However, the elderly is already an important patient group, and as the population ages and life expectancy increases, this group is also growing at the same time that the working part of the population shrinks. Lack of efficacy in elderly care may also have ripple effects that hurt the performance of the health care system as a whole. On most indications, therefore, coordination between health care and elderly care is becoming increasingly important, regardless of administrative divisions between the municipalities and the regions. Here too, digitalization will be able to make significant contributions.

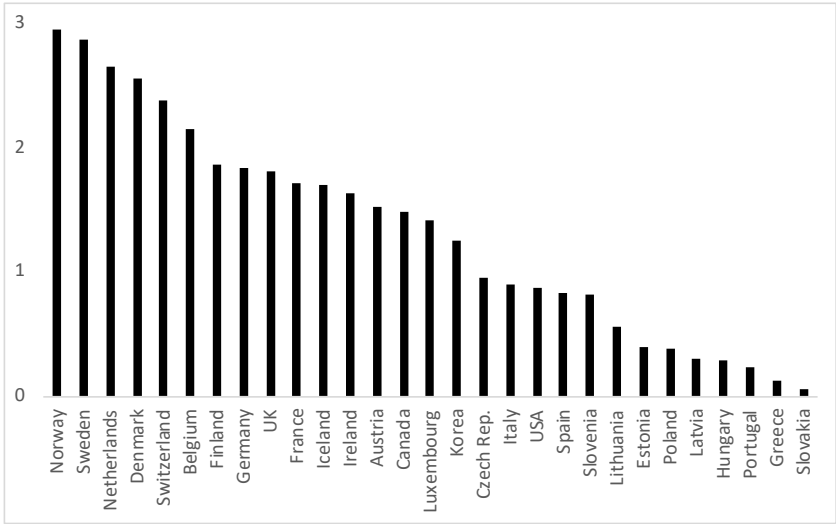
Costs for elderly care from an international perspective

Sweden is one of the countries that devote the most resources to elderly care within the OECD, see Figure 4.1. As the population ages, these expenditures will increase, and it will also be more challenging to maintain staff in the care professions. In Japan, with the oldest population in the world, there is already a lack of workers in many professions and, therefore, the country has increasingly been forced to use robots instead.[193] According to the Swedish Association of Local Authorities and Regions (SKL), recruitment to welfare jobs will be all more difficult in the years ahead, and it will be necessary with more efficiency and automation to deliver a good

[191] Stuart (2018), http://chan.usc.edu/npnl/.
[192] Liew et al. (2018), Anglin et al. (2017), Lefebvre and Liew (2017).
[193] Thunqvist (2017), Economist (2017), White (2017).

increase in the standard of welfare services.[194] Already today, Sweden is worse off than many other countries in terms of how access to health care is perceived by the elderly.[195]

Figure 4.1 Expenses for elderly care as a share of GDP in 2016.



Source: OECD.

New technology has the potential to improve several dimensions that are important for quality of life and opportunities for social interaction. Not least, loneliness is a problem for older people in communities with fewer children and grandchildren. It does not have to be as extreme as the horrific example discovered in Japan, where a man was dead for three years before anyone noticed.[196] In Sweden, the media report that many die alone without either presence of health care professionals or relatives.[197] There has been controversy about whether the percentage of those who die alone has increased or not. Regardless, it is a clear advantage if elderly people who live alone can have better social interaction.

Social networking on the web cannot replace physical contacts and socializing with close friends, but it can, to some extent, make social contact smoother. This feature may be especially true for the

[194] SKL (2018a).
[195] Vårdanalys (2017, p. 10).
[196] Onis (2017).
[197] SVT (2017a).

elderly who have friends in other places or have physical impairments that make travel difficult. The elderly's contact with their children and grandchildren is also made more accessible through several free services via smartphones. In the short term, however, many elderly end up in a situation of digital exclusion, although it is difficult to say how the situation will look in a future society with higher digital maturity.

So far, mostly the young use telemedicine in Sweden, but as the elderly become more used to digital technology, this may shift. One study shows that digital care is particularly useful for the elderly with impaired vision, but in order to achieve savings, there need to be fewer physical visits.[198]

Results from news media and web pages

There is extensive research on the health of the elderly, but as far as the effects of digitalization are concerned, knowledge stems mostly from other sources. In this section, we therefore mainly provide an overview of digitalization and support for the elderly from news services, magazines, and policy reports.

Technology, of course, is not a miracle cure for the difficulties of aging, but progress is being made in several dimensions, such as facilitating everyday management and improving quality of life. Much of the technology described in this paper can be used to improve the lives of the elderly by providing the following:

- Social interaction, even when staying home.
- Improved diagnoses, medication and rehabilitation.
- Strengthened opportunities for mobility outside the home.

Already the technology that is available today contains many opportunities for support. However, there are indications that many of today's elderly have lagged in technological development. One estimate is that in 2017, there were at least 400,000 elderly who for all practical purposes were completely outside digital society.[199] A

[198] Wittenborn et al. (2017).
[199] Olsson et al. (2017).

society that has focused on developing and marketing products to young people sometimes has difficulties adapting to the growing cadre of older people.[200] However, many companies are trying to establish themselves through digital services aimed at the elderly, and there are also public grants to support the commercialization of innovations. Table 4.3 below illustrates some pilot projects partly financed by the EU Commission.

Table 4.3 Selection of digital pilot projects for the health of the elderly that were partly financed by the EU 2017.

Application	Name
Robots that help with mobility, exercise and everyday management, such as showering.	Acanto, Accra, Enrichme, GrowMeUp, I-Support, eWall, PhysioDom-HDIM, Reach
Robots that help or provide support to deal with diseases such as Alzheimer's, dementia or Parkinson's.	Doremi, Great, Mario, Ramci, Silver, ehcoButler, In Life, ICT4Life, Petal, Success, Park-it
Robots providing support for communication with the environment or healthcare provider.	Emphatic, Captain, Picaso, Polycare
Monitoring of movement patterns to reduce the risk of falls and falls.	City4Age, My-Aha, Perssilaa, PreventIT, E-No Falls, Farseeing, Fate, I-Dont-Fall
Support for social life and games to maintain cognitive abilities.	Seacw, MI-Tale, Playtime
Help with medication and rehabilitation.	Medguide, GlucoBeam, Insulclock, Jumpair, Marsi, Tiredofcancerapp, Platinum, SeizSafe, Tech4Freedom

Source: European Commission (2018). For examples outside Europe, see Table 4.2.

Concerning support that makes it easier to live at home and still have social interaction, there are many technologies, some of which are already implemented in some municipalities. For several years, the municipality of *Västerås* has tested a project called “the Giraffe" (a tablet on wheels) to facilitate communication between health care providers and the elderly.[201] However, it competes with solutions from modern smartphones and tablets where the functionality has increased rapidly in the past decade.

Overall, the use of technology in the municipalities is relatively slow on the uptake. The National Board of Health and Welfare

[200] Economist (2016).
[201] www.giraff.org.

(Socialstyrelsen) notes that several goals for supporting evidence-based practices for achieving quality in social services have not been achieved; web-based development assistance applications in the care of the elderly have increased, but so far only cover one-fifth of the municipalities.[202] Moreover, while many municipal services can be streamlined for citizens through more automation, many citizen interactions stem from unintended consequences of the municipality's internal routines. An indication of this comes from Järfälla, where it has been found that approximately 32 percent of all physical visits to the municipal service center were unnecessary and had arisen due to patients' uncertainty about how manual cases were handled.[203] The National Board of Health and Welfare (Socialstyrelsen) also notes that municipalities' provision of e-services is low. The most advanced service so far is digital security alarms, which can, for example, alert health care providers in the event of a fall or other accident. At the beginning of 2017, just under three-quarters of the alarms were digital. Most municipalities also use passive alarms, while cameras for so-called night-time supervision are less common and for day-care remarkably rare.[204]

There are also various projects underway in municipalities to evaluate robots, including a "shower" robot in Karlstad, which should be able to increase the independence of the elderly and remove some hard work for the nurses.[205] Japan is the country that has come furthest with robots in elderly care. There, the robot "Pepper" is used to lead social activity and exercise at retirement homes.[206] In the future, this may be common in Sweden as well.

Table 4.3 also shows that similar robot services are being developed in the EU. Some of these activities are promising. However, public service, with its long procurement times, also risks providing expensive ad hoc solutions for services that are later incorporated free of charge into Apple, Google, or Microsoft operating systems. For example, technology for monitoring movements is already available in modern smartphones, which can provide the basis for apps that monitor the risk of falls or that can provide automatic emergency support when a fall occurs. Another

[202] Socialstyrelsen (2017, p. 7 and 2018a).
[203] SKL (2018b).
[204] Socialstyrelsen (2017, p. 24).
[205] SVT (2017b).
[206] Economist (2017).

example applies to specialized services and apps for the elderly to help build and develop social contacts. The elderly may have partly different needs than the young, but many may still want to communicate with their children or grandchildren and must then nonetheless use the same technology as the rest of society.

The late physicist Stephen Hawkings was able to write books despite a severe incapacitating illness by using advanced technology. Similar forms of technological aids are now increasingly being built into regular computers and smartphones at no extra charge, which is an aid to all –including the elderly. Smartphones can be controlled with standard voice commands; they can read emails, newspaper articles, and books, and provide a time or place-based reminder. GPS-based alarms are already incorporated into modern smartphones, and with so-called geofencing, it is possible to provide further location-based services.

Large parts of the technology described in other parts of this paper can also improve the diagnosis, medication, and rehabilitation for the elderly inside, as well as outside, the home. Today, relatively few elderly people use digital health care services and telemedicine, compared to the young (0–20 years).[207] That few elderly use telemedicine, however, is likely to change. As a group, they stand to benefit more than others from using telemedicine. The elderly often need multiple health care visits, but through telemedicine, they can avoid the effort and trouble of at least some trips for more simple or basic health care issues. Traveling to a health care center can in itself be tough for those elderly with mobility disabilities or those living in sparsely populated areas, not least during winter when snow and ice increase the risk of accidents.

The elderly with chronic diseases may especially benefit from digitalization. In Tables 4.1 and 4.2 above, we presented some examples of how digital monitoring and follow-up for those with cancer, diabetes, or heart disease led to more satisfied patients and reduced mortality rates. Costs are also decreasing. By monitoring key health parameters (blood pressure and pulse, to name two), patients can take more control of their health, and of course that applies to everyone, including the elderly.

[207] Blix and Jeansson (2018).

For example, the Swedish company *Coala Life* has developed a service to monitor the heart.[208] Through a small sensor and a smartphone, the patient receives surveillance and support from health care professionals at a cardiac information center. Technical problems and the onus of dealing with ECG-cords are thereby avoided. Also, the heart might not exhibit deviations from the normal on command or at the time of the measurement, and it is, therefore, an advantage that the patients themselves can perform monitoring regularly. Instead of being worried about irregular heartbeats, the patient can get help and support only when there is a need. There are the same advantages with other forms of digital monitoring, as for diabetes (see Tables 4.1 and 4.2).

Inaccurate medication is a significant problem in health care, and not least for the elderly, who may find it harder than others to read labels, mix doses, or remember to take their medication. One estimate is that 30–40 percent of emergency admissions of the elderly to hospitals are due to unnecessary problems related to taking medication.[209] There are new services on the market that help digital patients with the right medicine, such as *AIcure* and *Medguide*.

The prerequisites for proper control of medicines in Sweden are made possible by the central register established by the National Board of Health and Welfare in 2005. However, the so-called national patient register (NPÖ) has not come as far and is far worse off. It can be used by mobile health care professionals to find out what others have done, but about 60 percent of the municipalities state that they lack access to the system.[210] Low access to the system decreases the possibility of providing an overall assessment of the situation of the elderly in municipalities compared with the capacities of the county councils.

Rehabilitation from a bone fracture, for example, once a cast is removed, is an area where relatively simple technology can make a big difference. Health care professionals can monitor patients' progress on video links and provide support and advice. Instructions and advice can also be posted on YouTube or other platforms. Videos are often much easier to understand and follow than instruc-

[208] www.coalalife.com.
[209] Lenander (2017), https://www.med.lu.se/nyheter/170508_lenander.
[210] Socialstyrelsen (2017, p. 32).

tions from photocopies or brochures, which many people who have assembled IKEA furniture can attest to.

Dementia is a problem that increases with age. Many innovative solutions are now available. Several of the services presented in Table 4.3 are focused on counteracting dementia. There are also companies that develop bespoke games for that express purpose. One company offering such a game argues that its product can reduce the problem of impaired cognitive ability and that the beneficial effect persists for six months after playing the game.[211] There is also some research on this particular topic.[212] One hope is that various digital aids will be further examined in research and that knowledge will be improved on what the best methods are.

For the elderly, digitalization also enhances the possibility of increased mobility outside the home. At some point in the future, self-driving vehicles may become a reality, but long before this happens, the technology in today's rollers and so-called Permobiles has been further developed to help the elderly uphold or maintain independence. As can be seen from Table 4.3, there are also various robots currently in the development stage that help motivate exercise as well as support in everyday life, for example, walking. Several services presented in Table 4.3 contain different methods to increase the possibility of more autonomy by warning of risks, counteracting the deterioration of balance, and improving cognitive abilities. It remains to be seen how successful such technologies are, but there is no shortage of innovation.

In Sweden, a parliamentary bill came into force in 1994 that gave the right to those with disabilities to receive extensive support from a personal assistant. In a pilot project in the US, one tests a system with a personal assistant which instead provides *remote* support for the blind or those with impaired vision. The patient is equipped with a smaller video camera which, if necessary, can be connected to a care center where staff can help.[213] The blind can, of course, get assistance in shops and other places from staff or helpful citizens, but the new technology can give more independence and reduce vulnerabilities.

[211] neuroscape.ucsf.edu.
[212] Mishra et al. (2016).
[213] Donahue (2017).

5 The effects of digitalization on costs and quality

Economies of scale and regional autonomy

Digitalization and technological development can improve the provision of welfare in several ways. Technology provides the tools to streamline existing processes through various forms of automation. Indeed, technological developments have progressed quickly, and limitations on what a computer can perform are incessantly pushed back.

The first step towards automation is often to divide work into different parts, some of which may be defined clearly and thereby made faster through digitalization. This process applies, for example, to use machine learning to analyze images to detect cancer and replicate one of the oncologists' critical tasks, a technology that may even be found in regular smartphones shortly. Tasks, in particular, that are repeated in a predictable manner or based on massive amounts of data are susceptible to this kind of efficiency improvement. The benefits are more substantial the more often the standardized routine is implemented, and it is often only with extensive use that the unit cost of production drops sharply.

Scale effects from digitalization are fundamental but are, at the same time, almost trivial in that they are rarely mentioned in the academic literature that we have analyzed in this report. In large countries, where the effects of even small cost savings can be magnified through large volumes, there are more opportunities than in small countries to find potential gains from automating different tasks in health care. Since Sweden has a small population, the benefits are limited compared to the investment costs given the number of inhabitants. It is worth keeping this in mind when analyzing the international research literature. However, the

calculation for what is economic to automate can be more favorable if it is possible to use, existing or international, technology that can easily be adapted to Swedish conditions.

However, the lack of scalability in Swedish health care is also self-imposed due to the country's organization into regional self-governments (or county councils). This regional self-government is a pillar of the Swedish nation-state and is vital for legitimacy and keeping the country together. When decisions regarding central issues – such as education, health care, and elderly care are kept under the purview of the regions and the municipalities, citizens have more influence, and the distance to the political decision-makers is shorter. This closeness to the voters facilitates the conditions for having local accountability of politicians.

The difficulty for Sweden is that the economies of scale in some respects collide with the logic of local self-government. To be sure, some municipalities and regions have tried to cooperate in procuring the same system, but it has not been simple, and some attempted collaborations have been put on indefinite hold (or discontinued). The e-Health Agency (under the purview of the national government) had been tasked with developing a platform (*Hälsa för mig*) that would offer new health care services, but it has been shelved after running into a host of legal problems. To the best of our knowledge, there is this far no evaluation of the lessons learned from the agency's work, but the arguments for a platform have not changed.

The way forward should be to utilize the economies of scale of digitalization by identifying technologies where all regions can use a common platform that enables seamless communication between different care providers – whether they are private or public. Within the framework of such a platform, there should still be ample room to develop local services and innovation.

Such a list of technical areas and specification could be produced by SKL (the Swedish Association of Local Authorities and Regions), the national government, or a third party and then regions could voluntarily choose whether or not to join. A practical way forward would be to avoid being overly ambitious, but focus on the technology that would be easiest to implement and yet give the most effect. If the process works well, it can be expanded at a later stage. Local self-government remains essential to citizens, but welfare

services can and should be made cheaper and more accessible. One way to think about it is as either a temporary or permanent form of delegation to a central function in order to facilitate economies of scale.

In order for the platform to work, personal integrity and security are crucial issues that must be managed satisfactorily. The legitimacy of the whole system can be severely damaged if personal data come in the wrong hands. But rejecting any use of health care data by regions, private health care providers, or app developers is the wrong way to go. Platforms can facilitate the improvement of health care, provide more knowledge and research, and make it easier for third-party developers to create new services that the citizens want. To the extent that there are legal obstacles, policymakers should review regulation to obtain a better balance between the benefits and risks of a digital platform.

Network effects and new opportunities

An entirely different form of improvement from digitalization comes from the possibility of doing things that were previously not possible. In combination with scale effects, it is the network that opens up possibilities for new services. The more people who join the platform, the higher the benefit.

Telemedicine is a simple example of this. When patients and doctors connect via a platform, the computer can match their various needs and skills from among those that are available. Besides, it is possible to use matching in a host of dimensions that improve the content and quality of the services, including health care specialization and the language spoken between patient and health care staff.

Different patient groups and local initiatives, such as the US *Nightscout* project for diabetes, are possible when there are extensive networks to share knowledge and experience. Even patients with rare conditions can find someone with relevant experiences.

Networks and smartphones mean that patients' opportunities for self-care can take a big leap forward. A variety of technological tools for measuring health and health conditions can be used by the

patients themselves, and it becomes possible to use more services at low or no cost.

Also, networks provide ample opportunities for massive data collection. Instead of being limited to a few patients, knowledge about all, or significant parts of the population, is made possible. Here, there is a great benefit but also considerable risk to personal privacy and integrity. Today, we lack an ongoing process that constructively evaluates the benefits of expanding the use of health care data. Also missing is a process to build knowledge about what kind of health care is suitable for digital treatment, on the one hand, and physical care on the other. To achieve the potential benefits of digitalization, some form of centralization is necessary. We cannot determine where the boundary should be set in view to protect personal integrity. This is ultimately a political issue.

So far, the Swedish government and also the EU (through the so-called GDPR-directive) have placed notable emphasis on personal integrity. However, it should be possible to get more benefits from personal care data than today. We completely concur with the report from the Swedish Agency for Health and Care Services Analysis (Vårdanalys), which stated that "the collection and handling of the data can be improved without the need for privacy protection to necessarily be weakened."

Cost and quality effects from our literature review

Our reading of the literature is extensive but of course, not complete. Nevertheless, there is a value in summarizing the conclusions about the effects of digitalization. Tables 5.1 and 5.2, therefore, summarize cost and quality effects, which are discussed in this and the subsequent section, respectively. In both cases, we distinguish whether a result from the paper in question represents an improvement or a deterioration. Studies published in highly ranked journals are in boldface. It can be seen from Table 5.1 that a large number of studies show significant cost savings, and that this applies to several different areas in the health care sector. For example, the management of medicines at US hospitals has shown significant efficiency gains from digitalization.[214] Our review has identified

[214] Ker et al. (2014).

everything from improvements in reduced error in medication, and fewer hospital stays to AI-cancer assessments. Some studies set clear price tags on cost savings, but overall, it is difficult to do so.

Table 5.1 Cost effects of digitalization.

Costs	
Significant saving	Higher costs or slight cost reduction
Augestad et al. (2012), **Byrne et al. (2010)**, Canada Health Infoway (2014), **Cingi et al. (2015)**, Clark et al. (2014), Courneya et al. (2013), Darkins et al. (2015), Dullet et al. (2017), **Ekman (2017a)**, **Esteva et al. (2017)**, **Frisse et al. (2012)**, **Guy et al. (2012)**, Hassan et al. (2018), Hasvold and Wootton (2011), **Hedman et al. (2013)**, Hwang (2014), **Inglis et al. (2015)**, Jackson och Bradley (2014), Javitt (2014), Junod Perron et al. (2013), **Ker et al. (2014)**, Khan et al. (2015), **Kouskoukis och Botsaris (2016)**, Lammers et al. (2014), **Mehrotra et al. (2013a)**, Nguyen och Patrick (2014), NMHC (2014), Paré et al. (2013), Paré et al. (2014), Paul et al. (2018), **Pearl (2014)**, Stott et al. (2013), **Vermeulen et al. (2014)**, **Veroff et al. (2013)**, Warren et al. (2017), **Wittenborn et al. (2017)**.	**Adler-Milstein et al. (2013)**, **Ashwood et al. (2017)**, **Bailey et al. (2013)**, **Free et al. (2013)**, **Gurol-Urganci et al. (2013)**, **Kumar et al. (2013)**, Lee et al. (2013), Lee et al. (2016b), **Mold et al. (2015)**, **Morawski et al. (2018)**, **Nguyen et al. (2014)**.

Note: See Table A in the Appendix for a description of each study.

The overall picture is thus that there are significant opportunities for cost-savings without a detrimental effect on the scope of health care. Robots can do more work, 24/7, whereby the workload stemming from tedious and repetitive tasks is lowered for health care professionals, who can instead spend more time on core tasks, including follow-up or social support for patients. This type of improvement in efficiency has already taken place in financial aid assessments in the municipality of *Trelleborg* and parts of the activities of the Swedish Agency for Social Security (Försäkringskassan). With AI routines and automatic support for diagnoses, yet more time could be devoted to core tasks.

A non-trivial and straightforward form of timesaving occurs when the patients contact a doctor online and fill out a complete medical questionnaire. This does not just save time for doctors, but for patients too. Because patients fill out a digital form in advance, the doctor gets much of the information that a regular health care conversation must first deal with, such as social security number, address, and any allergies, to name just a few. When the telemedicine doctor initiates a video call or chats with the patient, the conversation can instead focus on the need for care, rather than on the minutiae of bureaucracy that form part of physical meetings. This simple step presents a clear and straightforward improvement

without either AI or any other advanced technology being deployed. Just as with SMS reminders, it is sometimes rudimentary technology that can lead to savings – when used on a large scale.

Efficiency potential in the public sector from research

Time savings are examples of small improvements. Many such small improvements can make a big difference in several welfare areas to achieve real effects, as pointed out in a report by The Ministry of Health and Social Affairs.[215] That there are potential cost benefits to be made in Sweden is also consistent with the part of the economic literature that compares the relationship between a country's inputs into public sector production to its output. The question asked in that literature is if a country should be able to produce better results given the number of resources that are invested. Overall, Sweden performs well when it comes to the services that are provided, but receives consistently lower grades on efficiency.[216] This is clear, for example, from a study published in 2017, whose main results are illustrated in Figure 5.1. The implication is that Sweden should be able to have more welfare for the *same* resources or the same welfare at lower costs.[217]

[215] Socialdepartementet (2010).
[216] Afonso et al. (2005), Afonso and St. Aubyn (2005a, 2005b, 2010), Jonker (2012), Medeiros and Schwierz (2015).
[217] Afonso and Kazemi (2017).

Figure 5.1 Efficiency and performance in the public sector, selected countries.

	Low efficiency	High efficiency
Low performance	Denmark, Finland, Greece, Italy, Portugal, Spain	Ireland, Japan, USA
High performance	France, Sweden	Canada, Luxemburg, Netherlands, Norway, Switzerland, UK, Germany, Austri

Source: Afonso and Kazemi (2017, p. 19).

There are some studies in our research overview that raise warning flags for faltering benefits from digitalization, and several of those are published in reputable journals. Our interpretation of this result is that benefits depend on how technology is introduced as well as how it is managed in terms of organization and governance. A common problem is that analog routines are replicated in a digital environment, without taking into account the fact that efficiency gains often require work routines to be rethought and adapted. Even worse, there is a problem of duplication of input-work for health care professionals, and sometimes analog and digital systems are used in parallel, or different systems are incompatible. The following are a selection of the deficiencies that were found:

- Unnecessary duplication and extra time for health care professionals.[218]
- Implementation where there is no synergy or network effect.[219]
- Electronic data improved compliance, but costs did not decrease.[220]
- Increased demand for health care via telemedicine physicians when the remuneration system is ill-adapted to digital health care.

[218] Nguyen et al. (2014), Mold et al. (2015).
[219] Lee and McCullough (2013).
[220] Bailey et al. (2013).

It is therefore essential to adjust governance, management and organization to take advantage of what technology can provide. Moreover, as we discussed in Section 3.1, the remuneration system for digital health care needs to be reformed in a way that does not become detrimental to innovation.

Quality improvements from digitalization

Table 5.2 summarizes the quality improvements identified in the research. There are a large number of studies that point to various forms of improvement. We have interpreted these quite broadly, and we cover everything from electronic data reducing the need for diagnostic tests to increased compliance from how patients follow their treatments. Sometimes improvements are made to both quality and costs. If, for example, a test becomes superfluous, time is saved for the health care professional, reducing cost, and the patient avoids the hassle or inconvenience of a possibly intrusive test, which can be viewed as a form of quality improvement. Table A in the Appendix provides a complete list, but here is a selection of higher quality effects:

- Improved accessibility in health care from telemedicine physicians.
- Digital platforms provide a higher quality of life for patients with asthma and allergies.
- Reduced mental illness problems through treatment with apps and telemedicine physicians.
- AI and machine learning software are better at identifying skin cancer than dermatologists.

Table 5.2 Quality effects from digitalization.

Improvement or higher patient satisfaction	Deterioration or slight improvement
Ashwood et al. (2017), Augestad et al. (2012), Backhaus et al. (2012), **Bailey et al. (2013)**, **Bender et al. (2011)**, Bursztyn et al. (2018), **Byrne et al. (2010)**, Canada Health Infoway (2014), **Cingi et al. (2015)**, **Corcoran et al. (2018)**, **Cottrell et al. (2012)**, Cottrell et al. (2015), Crotty et al. (2015), Dadosky et al. (2018), Dang et al. (2018), Darkins et al. (2015), **De Fauw et al. (2018)**, de Lusignan et al. (2014), **Di Santo et al. (2018)**, **Donker et al. (2013)**, Downing et al. (2013), **Esteva et al. (2017)**, **Flodgren et al. (2015)**, Forchuk et al. (2015), Giardina et al. (2015), Gierisch et al. (2015), Gordon et al. (2015), **Haenssle et al. (2018)**, Hamblen et al. (2018), Hammond et al. (2012), Hassan et al. (2018), Hedman et al. (2012), **Hedman et al. (2013)**, Hilty et al. (2013), **Inglis et al. (2015)**, Jackson och Bradley (2014), Jones et al. (2010), **Kauer et al. (2012)**, **Ker et al. (2014)**, Khan et al. (2015), Kocsis och Yellowlees (2018), **Kouskoukis och Botsaris (2016)**, **Kruse et al. (2015)**, **Lee et al. (2016a)**, Lee et al. (2016b), Leff et al. (2012), **Lilly et al. (2014)**, **Mehrotra et al. (2013a)**, Mehrotra et al. (2013b), **Mold et al. (2015)**, **Morawski et al. (2018)**, **Newby et al. (2013)**, **Nguyen et al. (2014)**, **Nguyen och Patrick (2014)**, NMHC (2014, Vol 2. P 195), **O'Connor et al. (2011)**, **Olthuis et al. (2016)**, Paré et al. (2013), Paré et al. (2014), Paul et al. (2018), **Pearl (2014)**, Polubriaginof et al. (2018), Proudfoot et al. (2013), Rees och Maclaine (2015), **Scheibe et al. (2015)**, **Schoenfeld et al. (2016)**, Sockolow et al. (2014), Stewart et al. (2013), Stott et al. (2013), van der Krieke (2014), Wang et al. (2017), Warren et al. (2017), Weng m. fl (2017), **Willmitch et al. (2012)**, Yenikomshian et al. (2018), Yu et al. (2018).	**Free et al. (2013)**, **Irizarry et al. (2015)**, **Kobus et al. (2013)**, Tegelberg m. fl (2018), Uscher-Pines et al. (2016),

Note: See Table A in the Appendix for a description of each study.

However, research gives an incomplete picture of the benefits of digitalization. When smartphones develop into powerful tools for care, more power in health care is shifted from the doctor to the patients. The smartphone can be used to monitor central health values (blood pressure and glucose to name a couple), give reminders about medication, and also make a diagnosis based on pictures. Patients with greater control of their health care can become more aware of their needs and thus require fewer resources from the health care system. A patient using a smartphone with a subscription or service via a networked medical center may need fewer physical visits.

The Internet and social networks also strengthen patients' knowledge and make it possible to exchange information and experiences, even for those with rare illnesses. Some in the medical profession express concerns about this development and point to the risk of incorrect self-diagnosis. There is some truth to this risk but is not a sufficient reason to stop development – even if it were somehow possible. It is reasonable to assume that better-informed patients overall are a benefit for themselves, their loved ones, and society as a whole.

Above, we discussed how simple time savings could be substantial. The same applies to quality and accessibility. The apps *GoodSAM* and *Mobile Retter* can save lives by quickly seeing if there

are trained health care professionals nearby in the event of an emergency. This form of matching in time and space and between the needs of patients and doctors would not be possible without digital platforms.

6 Conclusions

Knowledge about how digitalization affects health care has grown for many years, and recently, has increased considerably. Most important, there have been significant changes since 2007, when Apple introduced its first iPhone followed by the App Store (a few months later), Google developed Android, and IBM Watson began to be used for, among other things, cancer diagnoses. Platforms with open interfaces have attracted third-party developers who have created new smart services, in turn attracting more users, in a self-reinforcing process.

In the years after the turn of the millennium, several established companies were significantly affected by changed consumer behaviors concerning digital services. Some companies that had been early to develop advanced technology were overtaken by startups with more user-friendly – but not necessarily more technically advanced – systems. Technical excellence in processor speed and other performance issues became less critical, and value instead accrued from having cohesive ecosystems of applications and services.

The strength of digital platforms is based on *scale* effects and *network effects*, which means that the cost of reaching a large number of users is small and that the value for each user increases the more that participate.

Although 2007 was not a remarkable year for health care, it became, to some extent, the start of a convergence of technologies for consumers and large-scale enterprise operations. As smartphone ownership has become increasingly ubiquitous, more paths to health care services are now available, as well as new ways to measure and track personal health. Smartphones have also created a revolution of a kind in the health care sector, with more power shifted to the patients.

Significant benefits sometimes come from seemingly simple functions or improvements that save time and effort. SMS reminders for booked visits are noteworthy for reducing the number of no-show visits and thus unnecessary costs. Nonetheless, the Swedish health care system has not fully exploited the potential of direct, 24/7, digital contact with patients, or the fact that services can be delivered automatically and at a low cost. It is important not to underestimate the importance of small, but straightforward, technical improvements and the cost savings or efficiency improvements that these may bring. The digital history that telemedicine physicians use is another example of this, and could be implemented more consistently in all forms of health care – not just in telemedicine. Doctors can save a great deal of time by using the simple health care information that the patient has provided digitally, so that interaction with the patient can focus on more essential matters instead.

However, digital technology can also be used to implement more significant changes and improvements. Of course, health care is influenced by many other factors unrelated to technology, not least by how the care is organized, the remuneration system, and the aging population. However, our report shows that in most areas, there are great benefits from better utilizing digital technology in health care. Learning from other countries and from research about what has gone wrong and adapting systems and quality controls based on this should be a priority.

Most studies in our review indicate either significant quality improvements or cost savings, and sometimes both. Nevertheless, there is justified concern about problems that may arise when, for example, patients make their own diagnoses without sufficient knowledge, or when patients with minor care needs circumvent triage at the expense of patients with more significant needs. Health care professionals also report problems stemming from complicated and obsolete IT systems that require and waste time through duplication of work saved in other systems.

As society becomes ever more digital, citizens' expectations are also shifting. It is particularly evident that many patients appreciate digital services. Increasingly, citizens consume goods and services in digital ways, but in Sweden, they face a health care system that does not fully meet the way in which society is developing. There is also

the opposite problem. Many elderly are currently experiencing what is perhaps best described as a form of digital exclusion, and they often have difficulty using new services that are forced upon them.

There is certainly no lack of optimism regarding what digitalization can accomplish. Therefore, it is important to emphasize something that should be self-evident – that the benefits of digitalizing health care are by no means assured in Sweden. Since 2016, Sweden has had a political goal to be the best in the world at utilizing the benefits of digitalization in the health care sector.[221] However, there are many obstacles along the way, not least sluggish bureaucracy, complex organizations, and remuneration systems that sometimes provide the wrong incentives. A political health care vision that does not provide any meaningful guidance on how to address conflicting goals is also rather unhelpful. Being the best is not an achievable goal in its own, and it may deter attention from achievable progress building on the systems in use today.

Above, we emphasized the importance of not underestimating the time and efficiency gains from seemingly simple digital solutions. At an overall level, we particularly want to emphasize four issues:

1. More judicious work is required to reduce duplication and phase out incompatible systems. It is vital to avoid systems that are difficult to develop in the future, which "lock" health care providers into a particular platform with power resting more on the provider. A technical platform that serves as a common standard across Sweden will create the best conditions for utilizing economies of scale and generating network effects. Such a platform will make it easier for entrepreneurs to develop digital services that can reach across the country, unimpeded by regional borders. The utility of regional self-governments does not have to conflict with centralizing parts of the health care system when the overall benefits from digitalization can be considerable. However, this requires a deeper and more formalized cooperation between the regions, and that they delegate powers to a central player with a clear mandate for implementation and the budget and powers to match. If this does not happen and the

[221] SKL and Socialdepartementet (2016).

health care systems remain in today's rigid silos, then Sweden will gradually lag in achieving the benefits of digitalization. A common platform need not be inconsistent with local initiatives and innovation at the regional level.

2. Remuneration systems based on paying per visit conflict with the existing system, which is primarily based on capitation for listed patients. Remuneration systems also create problems by being complex, opaque, and contributing to more administration and bureaucracy. Reforms in the remuneration systems should focus on creating more transparency and simplicity for all actors. Red tape and unpredictable rules provide a slippery foundation for supporting innovation and long-term investments.
3. Personal security is a core concern, shown not least by any number of hacker attacks and misuse of data from social networks. At the same time, access to large amounts of data provides great opportunities to improve knowledge and diagnoses. With big data in health care, more lives will be saved, and unnecessary suffering can be reduced. How we value this in relation to the risks to personal integrity is of crucial importance, where security has so far been emphasized too unilaterally in Sweden. To the extent that the law currently prevents the benefits of a digital platform, policy-makers should review the regulatory framework. Here it is important to draw lessons from the difficulties the e-Health authority experienced when attempting to introduce an e-Health platform (*Hälsa för mig*), which aimed at offering various digital health care services. The profits and risks of using health care data should be coherently weighed against each other, and it is essential to find a way forward that is pragmatic in this loaded issue. At the same time, machine learning and AI assessments are also being developed in the public sector as well as in the private sector. Here there is a real and rising risk that there will be too *little* transparency. Citizens and authorities should require robots and AI to be able to justify their decisions, whether the robot's decision is about economic assistance from a municipality or from the Social Insurance Agency, or a cancer diagnosis. Society should

create a norm for what we require from AI and bring in into the legislation.

4. It is central that regions work together with their most valuable resource – the health care professionals. Digitalization is a demanding process that involves purposeful work at all levels. Initially, digital tools have mostly been complementary to health care personnel, but as AI and neural networks (convolutional neural networks, CNN) become better, competition between robot and health care personnel will increase in ever more dimensions. This has already happened in other areas. Robots are already well on their way to making better cancer diagnoses in some areas than physicians. It will, therefore, be necessary to have a strategy on life-long learning and to improve digital, as well as non-digital, skills in order to mitigate the risks of job polarization.

For patients, digitalization will make it possible to have *more* health care but with fewer physical meetings. For medical problems where there is a clear causal relationship, it should be possible to create more automated, yet personal, advice, share information via web pages, and facilitate telemedicine conversations with health professionals. The sparsely populated town of Storuman in the north of Sweden has worked with such methods for several years, and there are also positive international experiences. Telemedicine physicians in Sweden have been offering their services since 2016, and they have significantly reduced the problem of poor accessibility in primary care.

Concerning future possibilities for automated advice, this is of course far from problem-free. With development comes risk; in the same way, self-driving cars are not accident-free and will probably never entirely be. However, the benefit for patients of more care and counseling is of major significance, not least in areas that can be perceived as stigmatizing for those seeking help. Studies and experiences with mental illness illustrate the importance of such concerns, as it can be crucial that patients receive support quickly. Support in critical moments can also be decisive in reducing the possibility that the person at risk falls deeper into self-destructive behavior or commits suicide. In some cases, it may even be an advantage that communication takes place with a robot as a first

step, because the health seeker does not have to be worried about feeling second-guessed by the physician. Automated health care advice can reduce the threshold for seeking care, especially in areas where stigma occurs, as is the case with sexually transmitted diseases.

In order for automated advice to enter the mainstream and bring benefits, it is essential that e-triage can match patients with the right services in the health care system – to a website with information, tailor-made advice, or an online meeting with health care staff. The significant benefit with more automation is that it is possible to offer more care at little or no marginal cost. If it succeeds, it should be possible to reduce the workload on primary care and create more time for human contact – when needed.

For patients with extensive care needs, digitalization enables more personal control over health as well as wider choice. It is not necessary to visit physicians or hospitals as often if patients themselves can monitor their central health data. Experiences drawn from sparsely populated areas in several countries show how digitalization creates opportunities for patients who have too far to go to get to the nearest doctor, or for various reasons find it difficult to visit a physical care center.

Digitalization has resulted in significant upheavals in several established industries and created new players at the expense of those who have stuck to an outdated model or organizational form. Health care is not like other sectors, but when it becomes digitalized, new forms of tension arise in the health care demand and remuneration systems. Without reforms that ensure that the benefits of digitalization – its network and scale effects – will come into their own, these tensions will continue to grow.

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Appendix

Table A Main results of research papers cited

For an explanation of acronyms, see the end of the table. In the rightmost column, "HR" signifies that the study is from a highly ranked journal.

Paper	Main result	Comment	Cost	Quality	Area	Rank
Adler-Milstein et al. (2013)	Electronic journals so far have provided modest cost savings. For greater savings, organizational changes and changed payment routines are probably needed.	806 doctors in three areas were supported to introduce electronic records. Method problems mean that the result can be interpreted as a best-case scenario. Profits with a reform will increase with the number of people using the system through network effects.	-		EJN	HR
Ashwood et al. (2017)	Increased availability through online physicians mainly results in increased costs estimated at $ 45 per user. A minor share with 12% relieved primary care while 88% represented new demand.	Based on 300,000 patients in 2011–13.	++	++	TM	HR
Augestad et al. (2012)	High estimation for surgeons for video support and distance intervention, both for educational purposes and for avoiding travel. Easier carry out training with experts.	Compilation of the research literature. Knowledge and evaluation are still inadequate.	--	++	DK	-
Backhaus et al. (2012)	Telemedicine similar outcomes as usual meetings estimated by patients.	Literature review based on 65 studies based on a selection of 821. Availability improved.		+	MO	-
Bailey et al. (2013)	Electronic data reduced the need for diagnostic tests and improved compliance with emergency care guidelines, but did not lead to any general cost savings.	A review of 1252 patients in the United States.	0	++	DV	HR
Bender et al. (2011)	Some evidence that social networking on the web can help reduce pain intensity and inconvenience and facilitate self-care. Even that different forms of social network support can facilitate the management of pain for children.	Compilation of the research literature. Knowledge and evaluation are still inadequate.		++	PG	HR
Bursztyn et al. (2018)	Images from a portable camera were good enough for the assessment of optical disk edema.	Study based on an evaluation 109 patients at the Univ. Michigan.		++	DG	-
Byrne et al. (2010)	Over $3 billion net savings through e-health over a seven-year period in Veterans Administration, mainly through reduced workloads, reduced need to save physical movies, fewer unnecessary test scores, reduced hospitalization from error medication. Diabetic patients had better adherence to glucose tests, better control of cholestrol and eye controls was done more regularly.	The study quantifies quality improvements within glucose eye tests compared to other systems. Costs are based on a review of budgets in 2001–7.	--	++	KR	HR
Canada Health Infoway (2014)	Remote patient monitoring provides benefits for several chronic diseases, such as heart failure and diabetes. Reduces the need for urgent medical visits and improves quality of life and leads to higher patient satisfaction and compliance. Knowledge about the mix of technical tools needs to be improved. Important that doctors are involved in designing the service and that the service is large enough to achieve economies of scale.	A synthesis of reports and interviews. About 5000 patients in 19 different distance monitoring programs, which have grown 15-20% / year in scope.	--	++	KR	-
Cingi et al. (2015)	A digital platform (such as POPET) can provide significant improvements to health and quality of life for several patient groups, including asthma and allergies. The number of hospital visits goes down and there are fewer repeat visits. Improvements were also noted in productivity and mental well being.	Based on a randomized study of 327 patients.	--	++	KR	HR
Clark et al. (2014)	Total electronic information improves flow and reduces hospital time for patients. Estimates 20 minutes of time per 2 1/2 shifts per department and day.	Data 2012-13 from Australia.	--		IV	-
Corcoran et al. (2018)	Shows that the spoken language AI routine gives 72% chance of assessing signs of incipient psychosis compared to healthy individuals.	So far only in English and a small sample with 59 people. Predictions correspond well with manual routines to assess the risk of psychosis.		++	eTR	HR
Cottrell et al. (2012)	e-health with monitoring of blood pressure etc. was estimated by patients. Easy to measure and follow up.	Study 124 patients in the UK.		++	TM	-
Cottrell et al. (2015)	Follow-up of the study from 2012 shows that patients initially followed guidelines but that this deteriorated over time.	Study 2963 patients in the UK.		+	TM	HR
Courneya et al. (2013)	$88 savings per patient contacting e-physicians.	Based on 40,000 patients since 2010.	--		TM	HR
Crotty et al. (2015)	Only 3% of patients have not read their electronic messages on healthcare and medication within three weeks. Electronic communication generally works well but socio-economically weak groups read less than others.	Based on 49,778 patients in the US during 2005-2010. Probably a lower limit because smartphones have steadily increased in popularity since 2007.		++	KOM	-
Dadosky et al. (2018)	Patients who received video calls had a 17% risk of re-visit compared to 24% without video calls despite more advanced heart disease. High reported patient satisfaction and own knowledge.	Median age 81. Patients were supported by a trained nurse. Health status data were continuously measured and charged to cloud service, visible to healthcare professionals.		++	KR	-
Dang et al. (2018)	Video calls were appreciated by both patients and caregivers when treating mental illness.	94 patients with dementia were included in the evaluation.		++	MO	-

Darkins et al. (2015)	Cost savings of 4% over one year for patients receiving support and treatment at a distance (Care coordination home telehealth). Savings through fewer visits to healthcare and better control of medication. Costs for patients outside the program instead increased by 48%.	Based on data above about 5000 BC military (veterans) during the period 2009-12. The purpose was to reduce the need for hospital visits through better own control over health and medication.	--	++	TM	-
Davis Giardina et al. (2014)	Some positive results for patients having their own access to medical records, but the literature review is not clear.	Literature review 1970–2012.		0	eJR	HR
De Fauw et al. (2018)	Digital technology is used to improve diagnosis of eye diseases.	Robot just as good or better to diagnose 50 different eye diseases than doctors.	0	++	DIA	HR
de Lusignan et al. (2014)	Access to online records was practical and increased patient satisfaction. Concern for increased workload and for privacy risk.	Literary review based on 143 studies, mainly from the US and a few from Europe.		++	eJR	-
Di Santo et al. (2018)	Finds that a smartphone app can give better diagnostic performance than a physical examination for some disorders related to the arteries.	Based on a study of 438 patients.		++	DIA	HR
Donker et al. (2013)	Mental ills treated with apps lead to significantly less depression, stress and medication.	Literature review of a large number of essays, of which 8 met criteria for inclusion, which together analyzed 5 apps for depression, anxiety and abuse of medications.		++	MO	HR
Downing et al. (2013)	SMS reminders led to better follow-up of chlamydia tests 3–4 months after diagnosis. However, the number of persons taking the test are still rather few.	32 patients in Australia.		++	SMS	-
Dullet et al. (2017)	Access to network physicians leads to reduced travel costs and savings for the environment.	Based on 19,246 visits for 11,281 unique patients, which overall reduced their travels by about 3.3 million km or on average 245 minutes. Average cost saving $156.	--		TM	HR
Ekman (2017a)	Savings between SEK 1-10 billion per year are possible through digital visits.	A comparison between two models based on cost data.	---		TM	HR
Erlingsdóttir och Lindholm (2015)	eJournals challenge the medical profession and the project was realized by highly motivated individuals.	Based on archive material, in-depth interviews and media reports.		0	eJR	-
Escoffery (2018)	Women in the United States more likely than men to use e-Health tools.	Study 400 individuals 18–90 years.			TM	-
Esteva et al. (2017)	AI equally good at detecting skin cancer as a doctor.	Google's CNN neural network was trained on 130,000 images with 2030 different diseases. The robot as good as the doctors. The technology can be transferred to smartphones and used as support by non-specialists, thus providing a great potential saving as well as faster diagnosis.	--	++	CNC	HR
Flodgren et al. (2015)	No difference in the management of diseases between common healthcare meetings and telemedicine based on diseases such as diabetes, heart disease, respiratory problems, mental illness or drug problems.	Based on 22047 patients in 93 studies.		+	TM	HR
Forchuk et al. (2015)	Both quantitative and qualitative results indicate positive results for mental health from the use of smartphones and web-based support.	Study from Canada based on 400 individuals under 18 months. Smartphones usage showed increased satisfaction while web-based a slightt decline.		++	MO	-
Free et al. (2013)	Limited time gains with SMS reminders and some reduction in correct diagnoses with distance assessments.	Metanalysis of 42 studies, of which 11 were significant. Profits with SMS reminders and distance diagnoses need to be studied in more controlled experiments, especially as technology has developed a lot.	-	-	SMS	HR
Frisse et al. (2012)	Cost savings from the use of electronic information, mainly because fewer patients needed to go to emergency care.	On the basis of all emergency visits during a 13-month period in Tennessee.	--		TM	HR
Gierisch et al. (2015)	Small positive effects of measuring physical activity, which, however, do not necessarily mean better health or weight reduction.	Small positive effects of measuring physical activity, which, however, do not necessarily mean better health or weight reduction.		+	TM	-
Godleski et al. (2012)	Hospital stays reduced by an average of 25% through video calls.	Based on 98,609 patients in veteran affairs.	--		MO	-
Gordon et al. (2015)	Electronic communication can significantly improve communication between patients and staff. Patient satisfaction high.	313 patients, communication was via email or SMS.		++	SMS	-
Grünloh m.fl. (2016)	Electronic journals challenge existing work routines; the doctors expressed concern that they could not guide patients through oral dialogue and the risk of misunderstandings about diagnoses; In order to function, changed work routines require, but these need to be discussed and gaining a hearing.	Based on interviews.		0	eJR	-
Gurol-Urganci et al. (2013)	SMS reminders provide some improvement for missing visits to healthcare. Stresses that more knowledge is needed about risks and cost effects.	Based on 8 studies with a total of 6615 patients published by August 2012.	-	0	SMS	HR

Guy et al. (2012)	SMS reminders lead to a significant improvement in keeping booked times.	Review of 18 studies.	--	0	SMS	HR
Haenssle et al. (2018)	Cancer was better detected by AI than by doctors.	The results from Google's so-called Convolutional neural networks were tested in comparison with 58 dermatologists, including 30 experts.		++	CNC	HR
Hamblen et al. (2018)	Patient groups online can support each other at PTSD for war veterans and reduced stigma.	A web-based video service with war veterans who share their experiences.		++	PG	-
Hammond et al. (2012)	Electronic or telephone contact was no worse than direct calls between patient and doctor. The exception applies to patients with greater care needs. Supports the importance of more targeted interventions in therapy and better accessibility for patients with more frequent mental health needs.	Based on 39 227 patients in England.		++	MO	HR
Hassan et al. (2018)	Biggest gains with video calls for those with reduced mobility are reduced travel time and cost. The biggest obstacle was difficulty not being able to perform a complete neurological examination. Only few patients received reimbursement from public social insurance in the United States while it was much more common in Australia and Canada.	Based on a survey sent to 6056 MDS members in 83 countries, but a response rate of 9.1%. Some risk that the results have a bias.	--	++	TM	-
Hasvold and Wootton (2011)	Electronic reminders reduce missed visits by 39% while automatic reminders by 29%.	Review of 29 studies.	--	0	SMS	-
Hedman et al. (2012)	E-treatments can be seen as well established only for some mental illness, such as depression, panic and social phobia. If the usual clinical method works, e-treatment also seems to work.	Review of 103 studies based on a total of 12,374 patients.		+	MO	-
Hedman et al. (2013)	E-treatments for mental illness have substantial and lasting effects and are cost-effective.	Cost efficiency based on a sample of about 40 patients evaluated over one year.	--	++	MO	HR
Hilty et al. (2013)	E-treatments are effective and comparable to physical doctor visits for a variety of diseases.	Comprehensive literature review 2003–2013.		++	MO	-
Hwang (2014)	Telemedicine effectively supports the elderly to reduce the extent of hospitalization.	Meta Study.	--	0	ELDY	-
Inglis et al. (2015)	eHealth improves the treatment of heart disease, provides higher life scales, lower costs, and was accepted by patients. Reduced mortality.	Review of 25 studies.	--	++	KR	HR
Irizarry et al. (2015)	The patients' interest in using e-portals is strongly influenced by socio-economic factors.	Review of 120 essays. It is important that e-portals are designed so that as many patients as possible can use them.		-	KOM	HR
Jackson och Bradley (2014)	Web portal can make it easier for patients to monitor their health (blood pressure, etc.) and better interact with doctors. Particular advantage would be to allow patients to distinguish between serious and non-significant symptoms. Great potential to reduce unnecessary visits.	Review for Canada's e-health based on studies and experiences from the US.	--	++	DV	-
Javitt (2014)	Mhealth for diabetes leads to reduced costs by 10% on average for those insured in the United States and 7% for the elderly in Medicare.	Meta Study.	--		KR	-
Jones et al. (2010)	e-triage via the internet worked well and was appreciated by patients in terms of booking and follow-up.	Study in the UK.		++	eTR	
Junod Perron et al. (2013)	Text messages are cost-effective reminders of booked times that reduce absenteeism.	Based on study with 6450 patients.	--		SMS	-
Kauer et al. (2012)	Electronic self-care with smartphone increased self-awareness of the symptoms of mental illness, which led to better handling. Ideal as a support and aids in the first line.	Based on a study in patients in Australia.		+	MO	HR
Ker et al. (2014)	Digital technology improves medication, reduces errors and speeds up handling.	Cost review, comparison between different systems.	--	+	DV	HR
Khan et al. (2015)	E-triage of eye problems leads to better sorting of patients to specialists and better diagnoses. Reduced risk of becoming blind. The median waiting time decreased from 14 to 4 weeks.	A successful pilot project led to the use of an e-triage system of eye problems in South-East Scotland.	--	++	eTR	-
Kobus et al. (2013)	e-health created difficulties in documentation and follow-up of depression. To be useful, clinical information needs to be simplified and standardized.	Based on study of 200 adult patients with depression.		-	MO	HR
Kocsis och Yellowlees (2018)	Video calls open up a new form of strong pysoteriotic relationship to different patients and can also create therapeutic confidence in ways that ordinary conversations cannot.	Literature review.		++	MO	-
Kouskoukis och Botsaris (2016).	Telemedicine led to great savings and improvements in costs and social dimensions. Promising results for Greece which has several inaccessible areas.	A calculation of the present value of savings for healthcare at two islands: Patmos and Leros.	--	++	TM	HR
Kruse et al. (2015)	Almost 40% of the studies showed positive results from e-portals in terms of improved medication, follow-up, and care visits. Patient satisfaction is also better but overall weak results in median terms.	Review of 26 studies.		+	KOM	HR

Kumar et al. (2013)	The cost of investing in e-health is significant, but profits are unclear and should be carefully investigated. Studies find between $ 50,000 and 100,000 cost per intensive care unit and e-health contributed to a range of outcomes - from a USD 3,000 reduction in costs to an increase of USD 5,600.	Systematic review of studies 1970-2011 based on costs.	0	0	TM	HR
Lammers et al. (2014)	e-health and electronic transmission of clinical data led to approximately 10% reduction in repeated CT, X-ray and ultrasound examination in emergency rooms.	Based on data in California in 2007–10.	--		DV	-
Lee et al. (2016a)	Strong interest in patients using email and Facebook to communicate with doctors who do not match the interest of doctors. Speaks for developing secure systems for e-communication in healthcare.	Based on 4510 patients with chronic diseases.		+	KOM	HR
Lee et al. (2016b)	The Nightscout project is created by private individuals through open source software for those with type I diabetes. Through the social media, the project has received attention. It turns upside down on the classic care model where large companies deliver healthcare services.	Improves for patients but important to focus on safe treatment. Since the software is free of charge, no control is carried out by the US authorities normally responsible (FDA).	-	+	DB	HR
Lee och McCullough (2013)	Small benefits from digitization in American care. Inputs from digitization increased by 210% but created only 6% increased value in 1997–2007. Non-profit invested more in IT. Neither evidence of complementarity nor of network effects. Signs that IT investments are underutilized.	Study based on 309 emergency hospitals in California but the well respected Kaiser Permanente was not included in the sample.	+	0	DV	-
Leff et al. (2012)	Treatment of schizophrenia through conversation therapy with computer animated Avatar. Compared to a control group, the treatment led to a reduced intensity and discomfort of the discomfort.	Study based on 26 patients, some of whom received 6 x 30 minutes of conversation compared to a control group who first received seven weeks of regular therapy and then the Avatar treatment. Major clinical study is being evaluated by the South London and Madsley NHS Foundation Trust.		++	MO	-
Lilly et al. (2014)	e-Health in intensive care improves care and reduces mortality by better adherence to guidelines, faster response to alarms and more encouragement to use medical data.	American study with 118,990 adult patients from 32 hospitals.		++	eJR	HR
Mehrotra et al. (2013a)	Finding cost benefits with e-health and no differences in follow-up of patients. However, higher tendency to print out antibiotics during e-visits. The same follow-up as for physical visits.	Based on a study of patients with sinusitis and urinary tract infection.	--	+	TM	HR
Mehrotra et al. (2013b)	E-visits are mainly used by younger 18-44 and to a lesser extent 65+. Common reason is convenience to avoid traveling. No connection with income level.	A review of 5615 patient visits for sinusitis or urinary tract infection, of which about 7% were electronic.		++	TM	-
Mold et al. (2015)	Studies show that electronic access to medical records resulted in increased patient satisfaction in 80%, 77-87% reported better self-control. Of doctors, 73% reported that communication improved. Some increase in doctor's time but no data on injuries or safety leaks. Many patients are not prepared to pay for the possibility of electronic communication.	Studies show that electronic access to medical records resulted in increased patient satisfaction in 80%, 77-87% reported better self-control. Of doctors, 73% reported that communication improved. Some increase in doctor's time but no data on injuries or safety leaks. Many patients are not prepared to pay for the possibility of electronic communication.	+	++	eJR	HR
Morawski et al. (2018)	For patients with hypertension, a smartphone app only led to little improvement in the use of medicine and no difference in systolic pressure.	For patients with hypertension, a smartphone app only led to little improvement in the use of medicine and no difference in systolic pressure.	0	+	TM	HR
Newby et al. (2013)	E-therapy for mental illness is effective in controlled forms but unclear whether the results can be generalized beyond this.	136 patients divided into control group and test group, follow-up after 3 months.		+	MO	HR
Nguyen et al. (2014)	Electronic journals modest positive results in the form of improved administration, quality and coordination. At the same time, there were changes in workflows that affected existing routines in a negative way. Mixed results on quality and patient satisfaction.	Analysis of published studies by researchers in Australia. Raises socio-economic frictions as obstacles to effective contact between doctor and patient.	+	+	eJR	HR
Nguyen och Patrick (2014)	Machine learning works well to classify CT and MRI images to detect cancer. The costs can be significantly reduced.	Based on pilot studies at hospitals in Australia.	--	++	DG	HR
NMHC (2014, Vol 2. P 195)	Mental ill health can be treated with e-health and provides significant cost savings. e-health 1/5 of cost with antidepressants and 1/10 of psychological help	Based on a review of clinical data based on (quality adjusted life-year) QALY improvements.	---	++	MO	-
O'Connor et al. (2011)	Electronic support significantly improved glucose and blood pressure control in patients with type 2 diabetes.	Based on data from 11 health centers during 2006-07 with 41 participating doctors and 2,556 patients with diabetes.		++	KR	HR
Olthuis et al. (2016)	E-treatments for mental illness work well when controlled by doctors and are somewhat better than other methods, including online discussion groups.	Review of 38 studies with a total of 3214 patients.		++	MO	HR
Paré et al. (2013)	Heavy reduction in the number of health visits for chronically ill people with e-health, as well as on average shorter healthcare visits, especially for heart failure and COPD patients. Even to some extent fewer emergency visits. However, the number of home visits increases both during and after access to e-health. Cost savings total estimated at 41% compared to regular care, or CAD 1,557 per patient on an annual basis.	A limited selection of 95 patients in Canada are studied for 21 months. Previous studies have found savings between 1.6% -68.3%.	---	++	KR	-
Paré et al. (2014)	E-reservations are a win-win combination for patients and doctors. Most patients appreciate the development. E-reminders have also led to reduced missed visits	Review of experiences in Canada.	--	++	KOM	-
Paul et al. (2018)	Video calls have been used successfully in mild remote burns, with access to specialists. Reduces the risk of visible scars.	Patients in Poland got access to US specialists via the smartphone app.	--	++	TM	-
Pearl (2014)	Kaiser Permanente implemented a comprehensive e-Health system that increased in users from 4.1 million in 2008 to 10.5 million in 2013.	Has met with appreciation but obstacles on the way are pricing and replacement of services, extensive investments and the reception of doctors.	--	++	DV	HR

Polubriaginof et al. (2018)	Electronic journals make it possible to evaluate risks for genetic diseases within the family and improve diagnoses.	Based on 7.4 million anonymous observations.		++	eJR	-
Proudfoot et al. (2013)	Digital tools work well for mild-to-moderate mental illness, in terms of depression and anxiety. Facilitates support for work and social interaction.	Study in Australia with 720 participants.		++	MO	-
Rees och Maclaine (2015)	Video calling effective for treating mental illness.	Research review of 20 studies with 613 patients, most of which were post-dramatic stress (PSTD). Anxiety and depression were also treated.		+	MO	-
Scheibe et al. (2015)	E-referrals led to better communication between doctor and triage in rheumatology.	Based on 2383 e-referrals in 2008–12.		++	eTR	HR
Schoenfeld et al. (2016)	Significant differences in diagnostic quality between different companies with network physicians. Biggest difference in providing correct diagnosis for different forms of throat infections but minor for back pain and wheezing and urinary tract infection. The form of communication did not matter to the difference in quality.	Based on a selection of 599 patients in 2013–14.		+	TM	HR
Sockolow et al. (2014)	Productivity increased with e-health in the home through better documentation and follow-up.	56702 patients in the United States.		++	TM	-
Stewart et al. (2013)	Integrated care for elderly people in PRISMA improves the results in terms of participation and user satisfaction. IT support is expected to increase and should be better utilized.	Literature tour of 45 articles and 2 books on PRISMA.		++	ÄLD	-
Stott et al. (2013)	e-health for mental illness led to several improvements, reduced time for doctors and no reported adverse effects. No patients completed the program.	Few patients, only 11 but 14 weeks follow-up.	--	++	MO	-
Tegelberg m. fl (2018)	Missing scientific support for diagnosis via video call.	Based on a literature review of about 3000 studies, but selection criteria led to only two reports being qualified and in these there was no evidence.		--	TM	-
Uscher-Pines et al. (2016)	Online physicians less likely to order diagnostic tests, print antiobiotics and had fewer socio-economically weak patients.	Based on the Teledoc 4657 digital visits survey for California's 18–64. It is not clear whether under-representation of weak socio-economic groups was linked to the level of the fee. Unclear if there is an assumption that physical visits had a 'correct' level for ordering diagnostic tests.		--	TM	-
van der Krieke (2014)	e-health for mental illness at least as good as usual methods. No studies reported adverse effects.	Review of 28 studies.		++	MO	-
Vermeulen et al. (2014)	Electronic ordering system for medicine is cost effective.	Based on data 2005–8 in Holland.	--		DV	HR
Veroff et al. (2013)	Patients who receive extra decision support via telephone, email and the Internet result in 5.3% lower costs than the others. It was about fewer hospital visits and less need for surgery. Cost-effective.	Study 60,185 American patients in 2006–07.	--		TM	HR
Wang et al. (2017)	Robot analysis of CT images for lung cancer as well as specialized doctors.	The neural network method (CNN) does not use all information and can therefore be a valuable complement to classical methods.		++	CNC	-
Warren et al. (2017)	Clinically and statistically significant improvements in type II diabetes care with e-health to about 20% lower cost.	Based on a study of 63 patients. A small dataset can be difficult to generalize.	--	++	KR	-
Weng m. fl (2017)	Machine learning increases the accuracy of assessments of heart disease and leads to more patients being able to receive preventive care and that unnecessary efforts for others are reduced in scope.	Based on data from 378,256 patients in the UK.		++	DIA	-
Willmitch et al. (2012)	Telemedicine in intensive care reduces the length of hospital stay by 14.2%, intensive care days by 12.6% and relative mortality by 23%.	Ten intensive care units in five hospitals in southern Florida during 2005–7.		++	IV	HR
Wittenborn et al. (2017)	e-health effective support for the elderly who are at risk of impaired vision compared to only physical visits. However, not cost-effective for the elderly in low risk. Cost saving for the community gets bigger if at the same time leads to a reduced scheduled survey rate.	Review of Medicare patients in the United States.	--	0	ÄLD	HR
Yenikomshian et al. (2018)	Burn treatments improve when using video calls, as it becomes easier to reach the many specialists that often are required.	Analysis of patient experiences.		++	DIA	-
Yu et al. (2018)	Digital tools provide statistically significant reductions in symptoms such as anxiety after 1-2 months.	63 patients in a proof-of-concept study were evaluated		++	MO	-

Note: AST – Asthma, CNC – Cancer, DB – Diabetes, DG – Digital health improvement, DIA – Diagnos, DV – Digital health system, eJR – electronic journal, eTR – e-triage, IV – Intensive Care, KOM – Communication, KR – Chronic disease, KRD – Cardio, PG – Patient group, SMS – Text message, STD – Sexually transmitted disease, TM – Telemedicine, ELDY – Elderly care.

Note.: On costs, "---" is a very large saving "--" is a large saving; "0" is no saving; "+" is increased cost. For quality "++" is a large improvement; "+" little improvement, "0" no improvement; "-" is a deterioration

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