Changes in Medical Processes Due to Digitalization: Examples from Telemedicine

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1 Introduction

Healthcare systems which organize the main process of patient care (patient history—diagnosis—therapy) in the classical way, where the patient is treated either in acute outpatient medical practices or in hospitals, are running at their limits. This is seen in overcrowded waiting rooms, long waiting times, less time for examinations and doctor's consultations, and resulting problems affecting the quality of care (Irving et al. 2017). Long waiting times both for planned interventions and for providing acute emergency care are an issue for inpatient care in hospitals that have been known about for a long time, whether due to inadequate resource planning in hospitals or ineffective triage of clinical conditions according to severity (Sammut 2009). "Available statistics show that over 45% of World Health Organization (WHO) Member States report having less than 1 physician per 1000 population" (WHO 2020). Because of the increasing volume and importance of data in the medical field, more and more new tasks are being added to the core activities. These take up more time and, without resource rearrangement, create further pressures and difficulties in the core area (Kim 2015). One approach that has already delivered increased quality while reducing the burden on the care system is physician practices that are members of integrated medical care groups (Mehrotra et al. 2006). As they are networked with each other or with other facilities such as telemedicine centers and radiological facilities, they may have resources to improve quality and guidance for the patient that separate physician practices do not.

During the *core* process of medical care, first the patient's medical history is recorded. A doctor's appointment is made, at which symptoms are described and questions answered. Before arriving at a diagnosis, the patient history is

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followed by a physical examination, sometimes supplemented by blood tests in the laboratory or by certain radiological screenings. After a systematic consideration of the differential diagnosis by the physician, the diagnosis is made and a therapy proposal is provided (Adler and Hemmeler 1992). The information gained results in data, which is accumulated, analyzed, and evaluated in a *secondary* process, for example as part of studies, in order to draw conclusions from the data and to achieve improvements. Such data is no longer simply entered into various patient management systems (PMS). It is increasingly collected through various apps, wearables, and medical devices. The evaluation of health data, the emerging health-related e-learning methods for professionals and for the general population, as well as the important question of how to communicate about health properly through social media, are summarized under the area of e-health (WHO 2016). When the new term telematics is discussed, areas of the *tertiary* process are also addressed: anonymized data for control, planning, and billing (Berger et al. 1997).

Telemedicine has points of interaction with all three areas (primary, secondary, and tertiary process), which are strongly interrelated and have become even more intertwined with the new technologies. Frequently mentioned areas of telehealth include administration and support, public health, as well as research and health education. In the future, these could be included among the competences of telemedicine. Mentionable is that only 27% of European countries have a specific directive or strategy for telehealth (Peterson et al. 2016). Figure 1 shows how the processes relate to each other, work together, and influence each other.

Digitalization has become evident everywhere, including in healthcare processes. Digital technologies can be split into "*digitization*" and "*digitalization*" (Bloomberg 2018). Digitization means the mechanization, automation, and efficiency of the existing processes. Examples in healthcare—insurance card readers in medical practices and pharmacies, electronic patient files or electronically provided

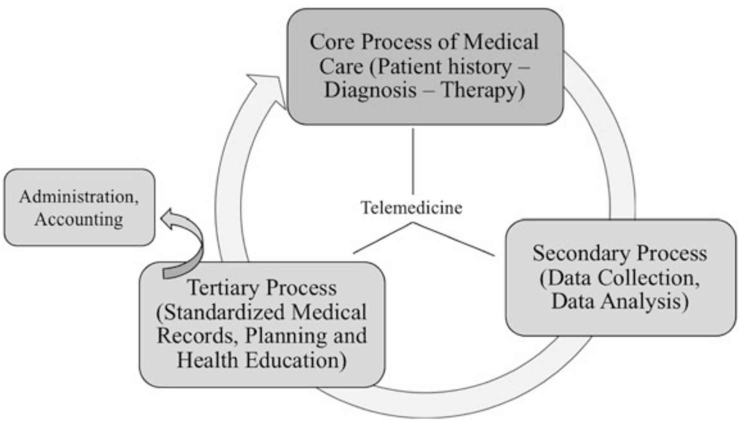

Fig. 1 The continuity of healthcare: the individual processes are connected, create parts of the other areas and flow back circularly into the next area. Source: author

prescriptions—have primarily been developed as part of a general implementation of digital technology. Associated challenges include organizational coordination of the interfaces and achieving corresponding evolution of the previous system. The term "digitalization" refers to the use of newly developed techniques which previously did not exist. Involving sensors of all kinds, tests, and digital applications, these techniques are used primarily for measuring various biological parameters, and secondly for data collection, analysis, and evaluation, increasingly with the help of artificial intelligence (AI). At this level, interface incompatibilities are overcome, systems are integrated, and new services are created. As these changes take place, sometimes in parallel, many different new terms are created. Telemedicine has also become charged with a new, expanded meaning. More and more segments from the areas just mentioned (e-health, telehealth) have now joined the original definition of telemedicine: medical services in the areas of consultation, diagnostics, therapy and rehabilitation, provided over geographical distances or time differences using various information and communication technologies (Bundesärztekammer 2015).

How have medical processes changed in the context of digital technologies? What challenges have to be managed? How can it be ensured that the information and data constantly emerging from the various fields of (tele)medicine is bundled in a standardized, qualified, and cost-effective way, so that it can be actively monitored and used efficiently for the individual and for scientific research?

The following sections give a brief overview of how medical care processes have already changed due to the new technologies. They describe the challenges, potentials, and success factors that have emerged for the future, as well as the kinds of suggestions for improvement that can be derived for the implementation of new digital paths in everyday medicine.

2 A Brief History of Telemedicine

As new technologies have brought about changes, terms such as e-health and telemedicine have become increasingly popular, and are attracting ever greater interest. But the term telemedicine is not entirely new. Where did telemedicine really start? The origins of telemedicine go back a very long time. In the Middle Ages, fire signals or flags were used to communicate information from afar, during outbreaks of leprosy or plague. Technological capabilities have developed rapidly over time. The first medical consultation by telephone was documented in 1879. Since then, this type of communication has been part of patient-centered healthcare. In 2001, the British Medical Association (BMA) classified it as safe and acceptable if—and this is crucial—it is carried out in the correct way (Vaona et al. 2017; Evans et al. 2003). As far as the various communication channels are concerned, radio has been an important means of communication, in addition to the telephone, when medical consultations have taken place on ships. Isolated areas such as parts of Alaska, the Arctic or Antarctica had to open up quickly to the telemedical possibilities that were still very space and technology intensive at that time (Glatz 2020).

Nowadays, computers and the internet are of course the most widely used channels for researching health issues. Besides classical search engines and websites, video consultations are possible and there are applications (apps) that can have a significant influence on our lives. The mobile web and its social platforms are now empowering millions of people to more easily share, communicate, and find applications for almost everything imaginable, including health issues. Since the introduction of smartphones, interaction using software has become even easier and more accepted (Boulos et al. 2014).

Another milestone on the digital highway is the increasing use of microdevices for recording vital parameters and biosignals. Contact centers that process these parameters using various types of communication technology are expected to develop into comfort contact centers providing services to citizens and bridging the gap between the patient's daily signs and their clinical profile. Intervention based on a large amount of such data and information could save thousands of lives every year. Contact centers could effectively use messages, warnings, or reminders to provide information to doctors and patients to help them make the right decisions (Balas et al. 2000).

3 The Main Process of Patient Care (Patient History—Diagnosis—Therapy)

The main process of patient care consists in taking the medical history and carrying out some tests and examinations—which allow various clinical conditions to be excluded or confirmed—in order to recommend an optimal therapy. For this process, it is no longer mandatory for the patient and doctor to meet in person. With the new technologies, it is possible to go through these steps even when the patient is in a completely different place than the doctor, with the process managed by video, chat, special sensors in watches, smartphones or on clothes, or indeed a combination of all of these. Among medical colleagues, too, discussions can take place independently of time and place, in the form of teleconsil. There are already a few examples of these approaches in preventive, acute, chronic, and individual medicine, but no bundled, widely applicable concept has yet been developed. Some of the examples mentioned are discussed below.

3.1 Telediagnostics

In *telediagnostics*, a disease is diagnosed without the doctor and patient being in the same room. Depending on the specialty, examples include teleradiology, teledermatology, telepathology, telepsychiatry, telecardiology, teleneurology, teleoncology, and telesurgery. Telediagnostics is often practiced in the form of *teleconsil*, in which an exchange between two or more specialists takes place using telematics (Telemedizin BW 2020). A successful example of the adoption of teleradiology is the case of the island of Sylt. Since 2002, all radiological examinations on the

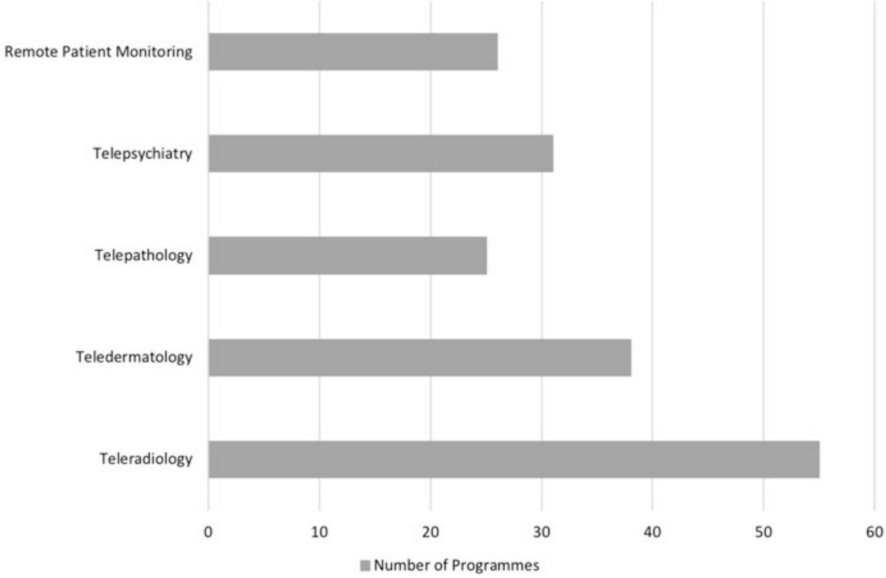

Fig. 2 Telehealth initiatives in the European region depending on the area of expertise. Data from Peterson et al. (2016): Source: author

island have been evaluated by telemedicine. By increasing the speed and actuality of medical findings, and due to the uncomplicated exchange of information among specialists, patient care has been significantly improved (Visus 2009).

Comparing the individual fields of specialists within Europe in terms of the frequency of telemedical projects, teleradiology comes first by far. This is also the area in which established programs exist, rather than just pilot missions or purely informational events without standardized processes (Peterson et al. 2016). Figure 2 shows the initiatives and programs by field of specialization for the European region.

3.2 Telediagnostics with Home Care in Acute Primary Care or Teletriage

This facet of telemedicine is also known as *teleconsultation*. Doctor's consultations unnecessarily carried out in person lead to overcrowding of surgeries and outpatient clinics and promote hospitalization. The resulting pressure influences clinical outcomes as well as important processes and problems in care (Bernstein et al. 2009). By applying telemedical care via teleconsultations in those scenarios where it is possible, 50% of cases can be treated with a high satisfaction rate. Services such as prescriptions, referrals, and certificates of incapacity for work enable care to be completed without the need to visit a doctor's practice or hospital (Stacey et al. 2004; von Solodkoff et al. 2020). The other 50% can be effectively and resource-efficiently triaged to the right doctor at the right time. Patient routes are thus optimally guided throughout the entire healthcare system. The ability for patients to discuss their current health problems with a doctor from home, via telephone or video, is already part of everyday life in European countries such as England, Sweden, and Switzerland (Steiner 2020).

Switzerland has had very good framework conditions for telemedicine and medical care using remote technology for some time. Thus Medgate, one of the leading physician-operated telemedicine centers in Europe, was able to start out in the outpatient primary and specialist care sector with the goal of enabling "360° healthcare" for patients at a very early stage, in the year 2000 (Fischer 2014). With a total of over eight million teleconsultations carried out and with up to 5000 patient contacts daily, Medgate has acquired broad expertise in this field. Medical teleconsultations via the Medgate Tele Clinic are safe and effective, and rated highly by patients (Blozik et al. 2011). For on-site consultations, supporting patients along the patient value chain, they also have access to Medgate Mini Clinics, the doctors and clinics of the Medgate partner network, and various managed care programs. As part of its digital strategy, Medgate has also launched an app with an AI-supported analysis and triage tool.

A national telehealth program in the United Kingdom observed not only cost reduction but also fewer visits to a doctor and a 45% reduction in mortality when using remote technology (Peterson et al. 2016).

The transition between primary and secondary processes is naturally continuous and cannot be sharply separated. The following section puts more emphasis on the secondary and tertiary aspects.

4 Further Processes of Patient Care (Data Collection, Data Analysis, Administration and Accounting)

Where exactly does the data come from? Firstly from the existing PMS that have been around for some time, and secondly from new sensors (Turakhia et al. 2019), input apps such as neotiv, the Alzheimer's disease early detection app (Düzel et al. 2019), AI-based diagnosis tools like ADA (Thurner 2020), complete diagnostic cells like the one in China (Onag 2019), cars (Van Berck et al. 2019), virtual reality (VR) glasses (Gerlof 2019), and also from specialized laboratories (Grünblatt 2014). Accordingly, there has been an explosion in the amount of data. Some examples from these fields are provided below.

Digital, more standardized medical records and invoicing channels have simplified the tertiary sector and made it more efficient. Previously, online appointment booking portals, such as Doctolib, merely enabled better staff and time resource planning. Through the Covid-19 pandemic situation they have expanded their service offering with teleconsultation platforms (Bourdon et al. 2020). The large amount of data, complex models, analyses, and the development of algorithms enable AI to be trained in such a way that causal relationships can be checked faster, more comprehensively and with a higher degree of complexity. The key influencing factors here are the quality and size of the AI data stock, and the training of the AI. Both aspects depend on the primary medical process: the more anamnesis data is entered, and the better structured it is, the more meaningful the calculation models become. Going a step further, the greater the precision with which the therapeutic interventions of the treating physicians are documented, the more causal dependencies, explanations, and even differentiations of therapeutic approaches become apparent, leading toward evidence-based, personalized medicine (Dilsizian and Siegel 2013).

4.1 Home Care

The classical understanding of home care stems from the care sector. Patients are assisted at home in everyday tasks by various means (provision of aids, bandage changing, meal preparation) and receive support so that they can stay in their familiar surroundings and recover there. In a broader and telemedical sense, home care likewise is intended to enable the patient to stay as long and as safely as possible in the home environment, but there are many more technical components, like telemonitoring of indicator parameters for chronic diseases. Telemonitoring means the monitoring of biological values measured via sensors. The resulting data is transmitted to a separate monitoring facility (Telemedizin BW 2020).

Chronic diseases for which telemonitoring and subsequent case management can typically be successfully implemented include chronic heart failure, diabetes mellitus, and chronic obstructive pulmonary disease (COPD) (Peterson et al. 2016). Some projects with other diseases like multiple sclerosis are already showing good results. Key parameters and opportunities for further diseases are being explored (Baker et al. 2020).

Approximately 2.5 million Germans suffer from chronic heart failure, and that number is increasing by 300,000 every year. This disease is the most common cause of hospital admissions. The Fontane study by the Charité University Hospital in Berlin has shown that telemedicine not only helps to reduce hospital stays (frequency and length of stay) but also brings the standard of care for heart failure patients in rural areas closer to that provided in urban areas (Charité 2020).

Much has happened in recent years with regard to diabetes and its telemonitoring. To the great satisfaction of everyone involved, huge progress has been made. One of the best outcomes of recent years has been the development and implementation of a fully "artificial pancreas" (AP) in the form of complex cooperation and coordination between several devices and measured values (continuous glucose measurement, an insulin pump, and an algorithm on a smartphone). The three devices work together smoothly. Blood glucose values measured by a continuous glucose measurement (CGM) device in the subcutaneous tissue automatically control the function of the insulin pump and thus the amount of insulin delivered, according to the principles programmed into the algorithm on the smartphone. Then the loop starts over, just like in a physiological pancreas. The telemedical monitoring of values and a corresponding alarm system have played an important role in patient safety and were essential for the safe application of this research method. Now that studies have shown that the AP system can be used not only under controlled conditions, but also in normal home settings, the system currently faces the challenge of finding appropriate funding to support its adoption in the everyday treatment of diabetes (Heinemann et al. 2016).

4.2 mHealth

mHealth uses mobile technologies to draw attention to, discuss, and teach health-related topics, all with the general goal of improving health. mHealth therefore addresses areas like prevention, health promotion, and well-being, through apps called lifestyle apps. Data on habits and behavior is collected throughout the day via wearable medical devices or sensors. Some 73% of European countries do not have an authority responsible for ensuring the safety and reliability of these applications. On the other hand, the use of these mHealth services has increased by 25% since 2009. It is highly recommended to establish an entity responsible for the quality and regulation of mHealth applications, to evaluate the benefits of mHealth and ensure good quality (Peterson et al. 2016). Aspects such as informed consent, licensing schemes, and liability rules need to be discussed and regulated, given that mHealth services are set to expand and gain a significant role in mainstream healthcare.

Taking a closer look at wearables, an amazing range of advanced technologies is already available. But technological progress has not only enabled the further development of existing devices, it has also helped to realize new detection techniques. In addition to the traditional electrocardiography (ECG) examination, the heart rhythm can also be determined from pulse curves recorded by photoplethysmography (PPG). To achieve the greatest possible accuracy, this method was validated from beat to beat via a simultaneously derived ECG (Vandenberk et al. 2017). PPG is based on changes in blood volume in the observed tissue. The tissue observed may be a finger, wrist, or other part of the body. During measurement, the tissue is illuminated by a light source such as light emitting diode (LED). Since the heartbeat produces wave-like changes in the blood flow and thus changes in light absorption and light reflection, the method can be used to measure heartbeats. The wave-like changes in the blood flow are recorded by a photodetector as a pulsatile signal, displayed and stored as a pulse curve. From this information, the heart rhythm is determined. Various studies have demonstrated a good correlation between the parameters recorded by ECG and PPG (Vandenberk et al. 2017; Koenig et al. 2016). For these reasons, the method was included in the screening recommendations of the European Heart Rhythm Association (EHRA) (Katritsis et al. 2017). The large-scale Apple Heart study with more than 400,000 participants delivered initial results on the ability of a smartwatch algorithm to detect an irregular pulse as a sign of previously undetected atrial fibrillation (Turakhia et al. 2019). Another study (Lahdenoja et al. 2018) presented a smartphone-only solution for the detection of atrial fibrillation. The smartphone's built-in accelerometer and gyroscope sensors are used for the analysis. Signals are taken directly from the thorax without an

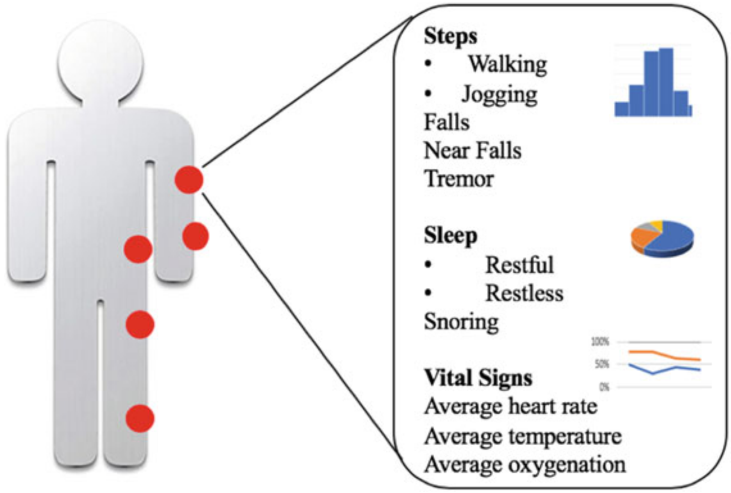

Fig. 3 Parts of the body where sensors can be comfortably worn and some parameters that can be measured, displayed, and recorded by the devices. Inspired by Baker et al. (2020). Source: author

additional external sensor. Accuracy of 97.4% (sensitivity 93.8% and specificity 100%) was observed in the study.

Smartphones can help to diagnose other diseases too and support more precise treatment, as in the case of multiple sclerosis (MS) (Schwab and Karlen 2020). MS is a disease of the central nervous system which can affect the entire brain and spinal cord. Parts of the nerve fibers are destroyed by their own immune cells, thereby disturbing the transmission of electrical impulses and the structure itself. Symptoms include paralysis, an inability sometimes to coordinate muscles properly or at all, and problems at the sensory level. The Floodlight Open app uses smartphone accelerometers and can be applied by people suffering from MS. The app is an innovative step revealing the potential of real-time remote patient monitoring. The associated long-term study, the Floodlight Open study, is intended to build an understanding of how long-term data collection and real-time evaluation of various key parameters such as mobility, motor function of the hand, cognition, gait and posture in people with MS contribute to optimal monitoring and fine-tuning of MS and its treatment (Baker et al. 2020). Furthermore modern medical devices are comfortable and convenient to wear on different parts of the body—wrist, hip, or ankle—and can detect physical activity through the use of accelerometers (Bradshaw et al. 2017). Figure 3 shows the parts of the body where sensors can be worn comfortably and some parameters that are recorded by the devices.

4.3 Highly Specialized Fields

In the fields of *aerospace* and deep-sea shipping, circumstances have meant that telemedicine has already been in use for a long time. Monitoring the condition of astronauts' health—with all manner of derived vital parameters—could only be done from Earth using telemedicine technology. Some of these newly developed monitoring methods then went on to be used in different contexts. Premature babies, as an example, often need to be monitored over a long period. With a special suit, however, all this can happen at home under quieter conditions. Sensors continuously record parameters from the baby such as blood pressure, pulse, and respiration. ECG and oxygen saturation can also be measured. All data is collected and analyzed so that in an emergency, the medical staff can immediately alert the parents or send an emergency doctor (Knapp 2001).

The term *"-omics"* is often used to describe something big: it summarizes parts of life science research such as genomics, epigenomics, transcriptomics, proteomics, or metabolomics. The different omics approaches provide valuable information about risk factors in the genetic background or due to environmental influences. They can be helpful for diagnosis or therapy recommendations. As biomarkers they can be relevant for clinical predictions such as prognosis, risk of relapse, drug response, and side effects (Grünblatt 2014).

4P medicine is also moving in this direction. 4P medicine prioritizes predictive, personalized, preventive, and participatory approaches (Jenkins and Maayan 2013). This allows in-depth biological data to be brought into play: molecular, cellular, and phenotypic measurements, even individual (now easily accessible) genome secretion analyses. Portable devices can be used for monitoring and alerting and can thus make a key contribution to promoting preventive medicine (Khemapech et al. 2016). Another essential component is to provide people with a comprehensive understanding of the many factors affecting their health, so as to be a step ahead before disease develops. The old focus of medicine, based on disease, needs to be shifted and directed toward how to stay healthy. The aim is to identify those at risk before the symptoms of disease appear, so that preventive treatments can be planned (Alonso et al. 2019).

Automotive health combines time spent in cars with health aspects. It considers all possibilities, from prevention to diagnosis and therapy. The willingness to take advantage of health services in the car is high. Health awareness among the general population has changed over recent years. People who spend a lot of time in their cars are able to collect health data while driving by using specific technologies integrated into the car (Van Berck et al. 2019).

Virtual Surgery Intelligence by apoQlar is a software that enables the virtual combination of CT and MRI images with a 3D model. Projected directly onto the patient, it provides exact anatomical guidance for the surgeon, who works with *mixed-reality glasses*. This can speed up the surgical procedure and increase safety (Gerlof 2019).

Ping An Good Doctor is a Chinese company offering specialized services. They have carried out the first pilot tests of various services, such as a one-stop online healthcare platform. This consists of an in-house diagnostic room and a *"smart medicine cabinet"* storing more than 100 common medicines. Patients have access to medical and health advice around the clock at any location, and can even take the appropriate medicine directly from the "dispenser" (Onag 2019).

5 Challenges and Potentials in the Implementation of the Changes in the Daily Medical Routine

Changes brought about by new technologies and emerging new services create some major challenges. These include the financing, legal aspects and required infrastructure, as well as respecting the interests of the various stakeholders. At the same time, medical effectiveness has to be proved, and economic efficiency demonstrated, based on valid clinical and especially health economic studies. The importance of these new services for the future and the possibility of their implementation must also be emphasized politically, so that these systems can receive appropriate financing and thus become practically feasible.

5.1 Challenges

The question of appropriate *reimbursement* is the biggest obstacle slowing down the practical, widespread implementation of new services emerging through recent technical developments, as in the case of telemedicine. In the various reimbursement systems in the outpatient and inpatient sectors as an example of Germany, accounting codes for telemedical services are largely absent. Required cross-sectoral telemedicine solutions are only viable in the long term if they are matched by lucrative cross-sectoral reimbursement. Further obstacles are seen in the lack of economic incentives for a balanced distribution of investments and proceeds. Policymakers need to create not only suitable conditions, but also financially motivating incentives. The *legal conditions* are often crucial when it comes to setting up various new forms of medical care in different countries. Some countries still do not permit purely remote treatment when the patient and practitioner have not previously met in person. In this case, there is no real possibility of establishing a truly comprehensive and broad-based medical digital solution. Other countries are not so strict, but nevertheless there are fields lacking legal certainty where clear rules need to be established (Dittmar et al. 2009). *Data protection* is particularly important in the medical field, as highly sensitive data is involved. Regarding telemedicine in particular, it is important for platforms to be secure under data protection law, and for clear rules to be established for the subsequent processing of the data (Berg 2004). It is beyond the scope of the present chapter to examine this topic in more detail.

Establishing and integrating *infrastructural systems* for the different requirements of new modes of digital health requires an initial investment and considerable effort. Ideally, such systems should be designed to be flexible from the outset, to facilitate combination with other systems and expansion. Maglaveras and colleagues (2005) have shown internationally—with examples from Greece, Spain, and the USA—that a multi-modular and multi-layered medical monitoring and consulting system creates an extraordinarily flexible and expandable structure. This can be established as a toolbox system, giving users access to their preferred applications even as others use different channels. The modular Medical Contact Center (MCC) is cited as an example of how such systems can be successfully used in the monitoring, treatment, and management of chronically ill patients at home. It offers valuable functions for medical personnel and for citizens. Data was input into the system through various established measurement devices (electronic weighing scales, blood pressure and pulse meters, digital thermometers, portable ECG recorders, and electronic glucometers). Interaction was also possible in the form of questions and teaching about the clinical pictures, both in text and audio format. This type of system can also be adapted to users' needs in terms of technological affinity and living conditions. In order to integrate different interfaces, a three-layer architecture is required, with an intermediate layer between databases and customer input. The intermediate layer integrates useful modules, and serves to link and translate between the other two endpoints. The key modules in the middle tier were the authentication module for data security and profile identification, the patient session module, where patient interactions take place, and finally the signal server module. Its task is to receive different signals from the home-monitored patient, which are recorded via the corresponding microdevices used at home. A three-layer architecture provides enhanced security, since client applications are not allowed direct database access. Additional processing modules like the clinician alert tool or detailed ECG processing were also implemented. Figure 4 illustrates the simplified set-up model of a three-tier architecture.

The system has achieved significant successes even just for the patients in this study. The number of hospitalizations per patient was 0.33 for the follow-up period, compared with 1.16 for the period before enrollment, while hospitalization days declined from 5 per patient to 1.5 per patient for the follow-up period. The main finding for the obesity subpopulation was a statistically significant reduction in bodyweight in the group of patients who used the platform as compared to the patients who did not. Home care services offered by the MCC system were well accepted by patients and clinicians, and contributed to a more efficient and higher-quality disease management plan. Following a similar three-tier principle, not only could the care of chronic and acute illnesses be well managed, but also the other potential future areas of modern telemedicine can be integrated in a customer-oriented manner. Solutions like this offer an attractive platform for healthcare delivery for the next generation, who are very interested in their health and in having more information about their health status. Designing telemedical centers in a multi-modular way would enable different facets of telehealth to be combined,

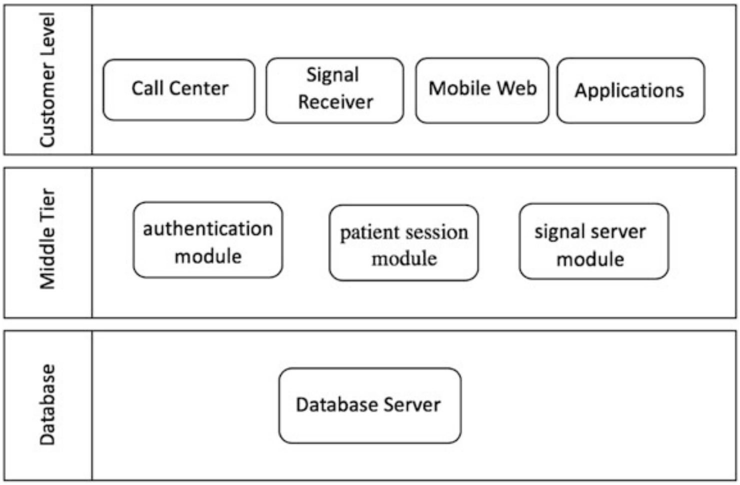

Fig. 4 A three-layer model to establish with the purpose of bundling and effective processing of several different digital input channels. Inspired by Maglaveras et al. (2005). Source: author

creating interfaces and further developing the guiding role according to the needs of individual medicine.

Every *stakeholder* in the healthcare system—whether hospitals or outpatient service providers, policymakers, or the patients themselves—has to some extent differing interests and different ideas and expectations about the new digital healthcare capabilities. Finding the overlaps and using them optimally is essential for lasting success. With increasing specialization, desired shorter hospital stays, more intensive outpatient care, and growing new digital areas, there is a fundamental need for telemedical instruments to cover treatment processes, organizational procedures, and new fields. The aim is to optimize resources, increase quality, and bring the focus of care back to the patients, so that they can also be retained as customers.

The valid cost analysis of a new procedure should be linked to a simultaneous measurement of clinical efficiency (Wohlgemuth et al. 2008). One difficulty in the *health economic evaluation* of e-health lies in its rapid, technology-driven development. The results at the time of publication may already be outdated to a large extent. Underlying applications and features may have been further refined, with an impact on cost-effectiveness, in part due to rapidly falling technology costs. Previous reviews of cost-effectiveness studies of telemedicine also show that accompanying health economic research could only be conducted in rare cases (Whitten et al. 2002). However, well-founded statements on the benefits of telemedicine, taking into account the preferences of patients, are essential for the acceptance of telemedicine. This is true for all sides of the healthcare system, and a requirement for its widespread introduction and reimbursement (Kristiansen et al. 2003). It is not easy to conduct a "value-for-money" or cost–benefit analysis in telemedicine. In addition to often fixed reimbursement groups and various billing systems, there is the problem of individuality. Not only is the patient as a human being different in each case, in terms of preferences within the medically meaningful range of treatment, but individual diseases also manifest themselves differently according to different genetic and environmental factors. Then there is medical freedom in terms of making assessments and the resulting consequences. Despite guidelines and standards, such decision-making also flows into a best possible solution, this is being human. Furthermore, infrastructural conditions such as practice and hospital density, specializations, and equipment are additional factors which influence the best possible decision for the patient. All of this should encourage us to conduct the classical cost–utility analysis on a more individual level. To make processes comparable, the medical and overall picture should perhaps be split into smaller parts and analyzed at the level of the respective medical case.

5.2 Potential and Success Factors

The new digital or remote medical care capabilities such as telemedical services give patients *access* to medical advice or even assessment by specialists, even in areas where medical care would otherwise not be available due to the great physical distance. If some questions can be resolved without real doctor contact, and the remainder can be optimally triaged into acute as well as chronic or preventive care, then *resources* (costs, time, personnel) are best allocated. This contributes to an overall improvement in the *quality* of care, as each party knows exactly what its role is and where the limits are. Feedback data flowing back into the telemedicine loop can help to track the performance of doctors and services and monitor standards.

A study of Switzerland's national influenza surveillance activities has shown that data gained through routine telemedical consultations can help to detect the early stages of an influenza outbreak, as surveillance reports would be available almost immediately. When the barrier to accessing teleconsultation is lower compared to face-to-face consultations, the sensitivity of detection is higher. In summary, the use of data from medical teleconsultations for influenza surveillance is feasible and could be transferred to other disease surveillance systems to support *public health* notification systems (Blozik et al. 2012). Due to larger data volumes with combined implementation of AI, telemedicine also has good potential as a valuable tool for *research*, especially in the field of rare deseases and multimorbidity clusters that are less prevalent.

There are numerous instances of pilot projects that could not be continued after the end of the funding period despite proven benefits. The projects do not succeed in getting into everyday operation, despite statements such as the following by the Commission of the European Communities, summarizing the situation in 2008: "Greater use of telemedicine could bring enormous social and economic benefits" (Paulus and Romanowski 2009). What are the significant advantageous factors that allow a project to continue operating?

The experience of recent years shows that sustainable concepts have become established and have proven to be viable if they were designed in a *standardized* way. Organized processes and bundled experience save time—a resource which is already scarce and valuable in healthcare facilities, where in many cases core tasks have already exhausted reserves. For a high-quality telemedical consultation, a *trained medical staff* with clinical experience is essential. Experience in medical triage (deciding which patient should be sent when and where for optimal care) and very good communication skills are helpful. Telemedical services should be carried out by a doctor or delegated under medical supervision. The most effective services can be provided by all the centers that have established themselves in this special field and can potentially be integrated further into existing healthcare structures (Braga 2017).

In medicine, some requirements and special characteristics are industry-specific. There is a certain natural variation in the course of diseases, as one example. The patient may deteriorate or improve according to circumstances, even without intervention or therapy. So there must be an opportunity for follow-up, to reassess the situation and re-evaluate the patient's condition. The time, attention, and trust to be gained from the patient side as well as the high level of patient safety from a medical point of view reinforce the assumption that a *24/7 service* is an important requirement for long-term success (Charité 2020). Offering consultations with experts in different specialties or longer accompanying programs such as nutritional or weaning advice can increase patient satisfaction.

Without a clear *legal and political framework*, and without an established, suitably attractive *reimbursement* system, which does not predominantly incentivize illnesses and interventions such as operations, but rather more preventive measures and independent consultations, the system will inevitably swim against the tide and the chances of successful implementation will be lower, thus the potential of digitalization in the healthcare system will not be fully exploited (Dittmar et al. 2009).

The *360° view* is essential to realize that one aspect is not enough without the others. In addition to medicine first and foremost, it is important to consider the economic approach, the infrastructure, and patient preferences, and work toward modern solutions (Fischer 2014). This approach will help to identify and constructively use the necessary overlaps between the different stakeholder interests.

6 Conclusion

Processes such as digitalization have fundamentally changed medical processes at all levels—whether the physical presence that is no longer absolutely necessary for making a diagnosis and suggesting a therapy, or the exploding data volumes of new digital applications in the medical field. It became clear that the available digital technologies and the resulting changes in the primary medical process have an enormous influence on the secondary and tertiary areas, as well as a dependency in the sense of feedback from these areas, which play a circular role in shaping the primary process. With effective process design there is great benefit potential in all of these fields.

The sensors of all kinds described above enrich the anamnesis with objective information. The patient history, which otherwise tends to be carried out on a one-time, retrospective, and reconstructive basis, is recorded on a more continuous data level in real time and in context. This creates new qualities and artifacts in the medical processes, which it is still necessary to learn to interpret and handle and requires a high level of resources. Healthcare systems organizing the main process of patient care (patient history—diagnosis—therapy) in the classical way, are running at their limits. These facts, together with the identified essential success factors for optimally managing the changes through new technologies, are an indication that new methods are necessary to cope with these changes. Basic management of collected data (analysis for assessment purposes, identification and categorization of the need for action with support for implementation, an alarm and advance warning function when certain limits are exceeded) as well as a first point of contact function could be covered by well-structured telemedicine centers with high standards.

At the same time, the economic and health policy challenges of an integrative, preventive medicine that goes beyond case-related billing should also be taken into account. First the political and legal framework has to be clarified and established in order to create a setting in which the remaining challenges, such as optimal infrastructural development, can be addressed. The continuity of healthcare established in this way moves the whole medical view of what to do when the person is ill more in the direction of how to stay healthy. The use of personalized medicine and digital technologies is changing our healthcare system and the way we think about health interventions and individual responsibility (Vilhelmsson 2017). With the internet and the active exchange of information among affected people and also with specialists, there is great opportunity to actively shape one's own health (Younesi and Hofmann-Apitius 2013).

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