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Holistic Decision-Making in a Digital World

Smart data integration and decision support along the patient pathway

In today's digitalized healthcare environment, informed medical decision-making increasingly depends on the smart integration of data. However, there are many barriers and challenges along the patient pathway. Complex decisions may fail because data is inaccessible or too extensive to evaluate, information is overlooked, or guidelines are ignored. All this can lead to inefficient and costly workflows and compromise clinical outcomes. This paper presents a platform-based approach that lives up to these challenges and offers holistic decision support along the continuum of care, bringing together a wide variety of healthcare data from diverse IT systems with a vendor-neutral design and preparing them in a user-friendly and meaningful way. Such a unifying approach, including digital applications powered by AI, can support operational decisions for optimized care processes as well as diagnostic and therapeutic decisions for optimized outcomes. In addition, today's digital solutions enable care teams and patients to connect more easily, providing a basis for patient-centered care and shared medical decision-making.

Introduction: medical decision-making, digitally reloaded

Decision-making is part of everyday life. It is a cognitive capacity for solving problems in the face of various options for action. In medicine, decisions have a clear goal: the good of the patient. And these decisions are shaped by professional standards, expert knowledge, the wishes of the patient, and the therapeutic possibilities.

In today's digitalized healthcare environment, achieving this goal increasingly depends on the smart use of medical data. Certainly, medicine is not data science. The art of healing consists not least of social interaction. Nevertheless, the continuously growing, multidimensional health data from electronic medical records, image databases, and other multi-layered, often fragmented IT systems is becoming more and more important for making up-to-date, patient-oriented decisions and designing care processes accordingly.

Of course, not all medical decisions are necessarily difficult. There are uncomplicated healthcare situations in which good basic medical knowledge is sufficient to find an expedient solution. Decisions are then straightforward. However, the decision-making becomes more complex as the number of diagnoses and management options increase, and as the amount of relevant patient data and the

risk of complications grow [1]. The challenge here is to integrate a wide range of data – from a variety of sources, such as clinical, radiological, or laboratory information, genetic and pathological findings, and insights into behavioral and social conditions – in such a way that the decision meets the highest possible quality standards and takes into account the personal situation and preferences of the patient (Figure 1).

Medical decisions occur along the continuum of care, from initial clinical contact to followup. For healthcare providers, the question is threefold:

• What needs to be done diagnostically and therapeutically?

• How can I use my resources in the process efficiently?

• And with whom should I share information and coordinate to achieve the best possible outcome for the patient?

This paper argues that digital technologies can indeed improve decision-making in all these dimensions and provide valuable decision support along the patient pathway. Complex decisions often fail because, for example, patient data is simply not accessible or is too extensive and unstructured, or because information is overlooked, or guidelines are not sufficiently observed.

A digital platform that prepares a wide variety of data in a user-friendly way and is simple and flexible enough to bring together patient information from diverse IT systems and institutions could help remedy precisely this situation. The ultimate goal is smart data integration that provides a more comprehensive picture of the patient and allows holistic decision-making in medicine.

Challenges along the patient pathway

Without doubt, the challenges that complex medical decisions entail are manifold and can affect various steps in the care process (Figure 2). A frequent problem is that relevant patient data may simply not be available or is too laborious to retrieve at the respective point of care. According to in-depth studies by the Mayo Clinic in the U.S., doctors in intensive care units, for example, may have to sift through thousands of individual data points in electronic medical records to extract the key pieces of information relevant to a patient's case [4]. Indeed, a substantial proportion of electronically stored data is never used in either the inpatient or the outpatient setting [5,6]. Of course, medical data in itself is meaningless unless it is transformed into actionable insights. "Data doesn't do you any good until you can turn it into information," the Stanford University School of Medicine stated in a trend report on the growing importance of data for healthcare [7].

One reason why a considerable amount of medical data remains unused may be the lack of analytics expertise. What is more, the sheer volume of data that physicians have to deal with can contribute to distraction, dissatisfaction, and burnout [8]. In a famous article from the 1950s, U.S. psychologist George A. Miller spoke of a "magic" number of seven information units that humans can simultaneously retain and process in short-term memory [9]. The growing volume of data in healthcare can therefore easily lead to what has been described as "information overload" with regard to digitalization as a whole.

However, some commentators of the digital transformation have argued that the problem does not lie in the mass of data itself, but rather in a "filter failure" – i.e., the lack of suitable selection and processing mechanisms [10]. For the case of healthcare, this means that advanced digital solutions are urgently needed that automatically analyze patient data and present it in a user-friendly and clinically meaningful way. The potential for using intelligent digital technologies to reduce inefficiencies in workflows and improve patient care should indeed be considerable. For example, about 30 % of radiological diagnoses are likely to be errorprone, mostly due to cognitive factors [11]. Such diagnostic errors can carry through the decision-making process and compromise therapeutic success.

“Data doesn’t do you any good until you can turn it into information.” Stanford Medicine 2017 Health Trends Report

In addition, therapeutic decisions may not comply with clinical guidelines. This, in turn, can not only increase the risk of complications and readmissions, but also push up costs and length of stay [12]. In other words, decisions that do not take into account the best available knowledge and information affect operational efficiency and clinical outcomes alike.

A platform-based approach to smart data integration and decision support

It is clear that these difficulties are hard to solve without powerful digital decision support. The modern concept of clinical decision support not only includes automated alerts to avoid errors, but also encompasses clinical guidelines, patient data summaries, condition-specific order sets, diagnostic support, and contextually relevant reference information. The overarching goal is to digitally provide “general and personspecific information, intelligently filtered and organized, at appropriate times, to enhance health and health care” [18].

A growing number of studies underpin the value of advanced decision support systems. For example, a machine-learning algorithm can help to avoid unnecessary CT scans in children with only minor head injuries [19]. AI-based approaches could also facilitate surgical decision-making [20]. In addition, higher support systems in oncological care are likely to increase adherence to guidelines, reduce treatment costs, and ease the workload of physicians in aftercare [21].

Siemens Healthineers has recently developed a comprehensive solution, the “teamplay digital health platform”, which can combine many of these advantages. The platform and applications connected to it support operational decision-making for efficient workflows as well as diagnostic and therapeutic decisionmaking for optimal outcomes. In addition, “teamplay” enables doctors, nurses, and patients to connect more easily, providing a basis for patient-centered care and shared decision-making (Figure 3).

Indeed, the “teamplay digital health platform” can represent a digital backbone for healthcare providers, as it operates system- and vendorneutral through various interoperability standards. This means that data from existing IT systems within an organization can be integrated and also shared across institutional boundaries – for example, with other hospitals, outpatient practices, or pharmacies.

The basic philosophy of the platform is to support decision-making along the entire patient pathway with a uniform but flexible IT solution. Through a wide variety of individual applications and extensions, which are available via an integrated digital marketplace, the platform can address multiple problems in various clinical fields (e.g., radiology, oncology, cardiology) and at different points in the care process (Figure 4).

Some concrete successes can be highlighted for both operational and clinical decisionmaking. For example, MedStar Health, a large health network in Maryland and Washington, D.C., in the U.S., has succeeded in significantly improving the coordination of image reading Figure 4: Improving data integration and decision-making along the patient pathway (examples of Siemens Healthineers applications in brackets) by subspecialized radiologists using the “Medicalis Workflow Orchestrator” application. In the network’s fragmented IT landscape, this represented a major advance [22]. “We had a jury-rigged IT system, and had no way to load-balance the workload across the system,” recalls Steven Brick, Physician Executive Director for MedStar Medical Group Radiology. At that time, 110 radiologists and nuclear medicine specialists were working with nine different picture archiving and communication systems (PACS) and five different radiological information systems for the 10 hospitals in the network. The availability of subspecialty expertise varied greatly depending on the time of day and location, as images could not be easily exchanged for reading.

By implementing the “Medicalis Workflow Orchestrator” together with a unified viewing platform, it was possible to establish a combined worklist, allowing all MedStar radiologists to work together as one team regardless of their location. This not only eliminated staffing problems, but also made

radiological subspecialty expertise constantly available throughout the network – a prerequisite for fast and precise clinical decisions.[1]

Similarly good experiences have been made with a wide range of other “teamplay” applications (Figure 5). “Using the teamplay digital health platform has given us access to digital solutions that we can trust,” says Robert Day, COO at Zwanger-Pesiri Radiology, a multi-site radiology practice in New York, U.S., performing over 3,500 scans a day.

1 The statements by Siemens Healthineers’ customers described herein are based on results that were achieved in the customer’s unique setting. Because there is no “typical” hospital or laboratory and many variables exist (e.g., hospital size, samples mix, case mix, level of IT and/or automation adoption) there can be no guarantee that other customers will achieve the same results.
2 Information is derived from a statement by Siemens Healthineers customer Dr. Ernest Barrientos Manrique, Health Time Medica, Spain.

3 Barmherzige Brüder and Vinzenz Gruppe, Austria | 4 Weill Cornell Medicine, U.S. | 5 IATROPOLIS, Greece | 6 Zwanger-Pesiri Radiology, U.S. | 7 Massachusetts General Hospital, U.S. | 8 IRMAS, France | 9 MedStar Health, U.S. | 10 HT Médica, Spain | 11 University Hospital Basel, Switzerland | 12 Heart and Diabetes Center North Rhine–Westphalia, Germany

With the performance management app “teamplay Usage,” Zwanger-Pesiri was able to increase MRI throughput from two patients per hour to three, while with “teamplay Protocols” it saved 90 % of the time spent on editing and distributing scanning protocols in the CT and MRI fleet.[1]

“Using the teamplay digital health platform has given us access to digital solutions that we can trust.”
Robert Day COO, Zwanger-Pesiri Radiology, New York, USA

The network also uses “AI-Rad Companion,” which is an AI-supported, cloud-based image interpretation tool for different modalities and body regions. The tool is one of the core apps of Siemens Healthineers’ clinical AI portfolio and, for example, supports the analysis of CT scans. The Spanish radiology service provider HT Médica, for instance, found that in one out of seven chest CT studies re-analyzed with the “AI-Rad Companion,” the software delivered additional valuable information that had not been noticed during the initial reading.[1,2]

In general, AI-based diagnostic support is increasingly finding its way into clinical use, with a growing number of approved applications for various clinical questions [3]. However, AI also holds great potential for better therapy planning.

Exactly this is the aim of Siemens Healthineers’ “AI-Pathway Companion,” a recently developed comprehensive software system for data-driven decision support. “The AI-Pathway Companion gives a very rapid overview of the patient and helps to reinforce treatment decisions,” says Heinz Läubli[13], Senior Oncologist and Head of Cancer Immunology Laboratory at Basel University Hospital (USB), Switzerland.[14]

At USB, the “AI-Pathway Companion” is already being used in clinical routines to improve the multidisciplinary management of prostate cancer patients. The digital tool aggregates patient data from multiple sources[15], such as electronic medical records, imaging archives, or – via natural language[16] processing – even written texts. The information is automatically processed and displayed in structured form. This makes it easier and faster for a multidisciplinary team to prepare and discuss an individual patient’s case and to decide on a tailored treatment plan.[14]

“Software like this will lead to better quality of care,” agrees Helge Seifert[17], Head of the Department of Urology at USB. A second clinical implementation project is underway at Radboud University Medical Center in the Netherlands. In addition, the “AI-Pathway Companion” is in development for breast and lung cancer as well as coronary artery disease.[14]

A major strength of the application is that it integrates clinical guidelines, individual risk

stratification[18], and the patient‘s preferences, thereby helping to make evidence-based and transparent recommendations for various treatment options. By mapping out where a patient is in the treatment pathway, it also facilitates discussion between doctor and patient on how to proceed.

Here lies an important focus of the “teamplay digital health platform” to better network not only data but also people. For instance, the “eHealth Solutions,” a family of various software packages, allow patient-specific data exchange across institutions on the one hand, and enable closer and expanded communication between care teams and patients on the other.

This is in line with a general trend: patients are developing a new, more responsible selfimage – and consequently want to participate in medical decision-making.

13 Heinz Läubli is employed by an institution that receives financial support from Siemens Healthineers for collaborations. 14 The statements by Siemens Healthineers’ customers described herein are based on results that were achieved in the customer’s unique setting. Because there is no “typical” hospital or laboratory and many variables exist (e.g., hospital size, samples mix, case mix, level of IT and/or automation adoption) there can be no guarantee that other customers will achieve the same results. 15 This function is supported by AI-Pathway Companion Connector. 16 NLP supported languages: English, German, Dutch. 17 Helge Seifert is employed by an institution that receives financial support from Siemens Healthineers for collaborations. 18 This function is supported by AI-Pathway Companion Prostate Cancer. Prerequisite: All data is available as required by guideline; Feature dependent on quality of input data. AI-Pathway Companion Prostate Cancer VA10B supports NCCN and EAU guidelines.

Changing roles in healthcare: involving patients through digital health

Digitalization comes along with changing roles of doctors and patients. For example, online searches for health information by patients are commonplace today and complement visits to the doctor. At the same time, the increasing importance of chronic diseases, the ubiquitous spread of mobile devices, and the development of connected wearable sensors are key drivers of mobile health [23]. Particularly in the case of complex chronic conditions such as diabetes or inflammatory bowel disease, which affect the entire social life, digital health applications can contribute to improved selfmanagement and reduction of fears, stronger patient empowerment, and shared decisionmaking [24–26]. Finally, from a consumer’s point of view, the digitalization of everyday life naturally raises the expectation of being able to ask providers questions or booking appointments online [27].

While not all social and age groups are adopting digital health technologies to the same extent or at the same speed, digitalization can ideally contribute to a cultural shift from traditional to collaborative care, with shared decision-making as a new norm [28].

Indeed, research evidence suggests that digital health, for example in chronic heart disease, can not only empower patients and enhance communication with caregivers, but may also support health-promoting behaviors, improve medication adherence, and reduce the number of hospital stays [29 –31].

An exemplary project is a telemonitoring program for heart failure patients (“HerzConnect”) at the Heart and Diabetes Center North Rhine–Westphalia in Germany. Patients are equipped with mobile ECG monitors and blood pressure sensors. The collected data, together with the patient’s weight and subjective well-being, is transmitted via smartphone to the care team in the clinic, which tracks the parameters on a user-friendly dashboard. For their part, doctors can reach patients directly via text messages. The networking becomes possible through Siemens Healthineers’ “teamplay” app “myCare Companion”.

A major goal of the project is to prevent cardiac decompensation and hospital admissions by early intervention and therapy adjustments, thereby improving patients’ quality of life. In a second step, an AI-powered central worklist can be used to prioritize those patients who require special support.

Siemens Healthineers also developed a related app during the COVID-19 pandemic. This app allows patients in quarantine to remotely transmit their body temperature and oxygen saturation, thus keeping infectious persons away from hospitals (see also excursus “Telehealth in the COVID-19

pandemic, and beyond").

Other applications to advance remote communication with patients are part of the Siemens Healthineers' family of "eHealth Solutions," including a patient portal for uploading and downloading of medical data and "Virtual Visit," which enables video consultations.

Regardless of the specific application, however, the digital involvement of patients has a general effect: it creates a constant feedback loop between the care teams and the people they care for. The patient pathway becomes a cycle of care (Figure 6).

Telehealth in the COVID-19 pandemic, and beyond

COVID-19 is transforming healthcare. Given the concern that infectious patients could introduce the coronavirus into hospitals, video consultations in particular have experienced an unanticipated boom at many hospitals.

"A sizeable proportion of outpatient visits in various settings can be clinically managed effectively from a distance," stated a recent editorial on the lessons learned from current changes [32].

For example, in a rapid response to the COVID-19 crisis, NYU Langone Health, a large academic healthcare system in New York City, increased the number of videobased emergency consultations between the beginning and middle of March 2020 from about 80 to over 1,300 visits per day [33].

According to the case report, the increase was even larger in non-urgent care, where virtual visits represented more than 70 % of all ambulatory encounters at the beginning of April. Patients of all ages quickly became used to sharing their biometric data via a patient portal, tightly integrated into the network's electronic health record. What is more, patient satisfaction with the video visits remained constantly high despite the rapid adoption of telemedicine, also by inexperienced physicians.

Langone Health had already introduced its virtual care infrastructure, including a dedicated patient app, in 2018, and the case may indeed seem particularly successful, but it is no exception. According to a recent study on telehealth adoption in Europe, Onkologikoa, a cancer center in the Basque Country in Spain, deployed Zoom for video consultations at each of its 30,000 workstations shortly after the pandemic began [34]. Likewise, the Hospital of Dénia in the Valencia Region in Southern Spain also introduced Zoom to manage patients at home, with an astonishing 80 % of them agreeing to virtual visits and finding them easily accessible. Hospitals in Italy and Denmark have had similar experiences.

What will remain of it in the future?

On the one hand, video-based care will hardly be used to the same extent as in the exceptional situation of the incipient COVID-19 pandemic. Nor will traditional barriers to telemedicine such as reimbursement, interoperability, and data privacy issues simply disappear in the post-COVID-19 world. On the other hand, observers agree that the pandemic has led to a new culture and acceptance of remote care among both patients and doctors, with a shift from the primary use of telemedicine for chronic diseases toward everyday care situations and first-visit patients.

It is likely that the positive experiences will raise future expectations among patients regarding the comfort and digital accessibility of healthcare services. Providers, for their part, could make greater use of telemedicine as a triage instrument to avoid unnecessary treatments and channel patients more effectively.

"A sizeable proportion of outpatient visits in various settings can be clinically managed effectively from a distance."
Bashshur et al. 2020

Not least, the digital and less traditional forms of communication in telecare could further reduce the hierarchies between doctors and patients and lead to their increased involvement in medical decision-making.

Staying flexible during the transformation

Digitalization is a continuous transformation. It is clear that today's IT architectures must be able to grow with changing needs and integrate new features. Indeed, according to an international survey, three out of four healthcare executives believe that digital platforms – fundamental IT solutions that incorporate previously disparate functionalities, connect things and people, and foster innovation – enable their organization's business strategy or even are at its core [35].

Siemens Healthineers has designed its digital health platform as a flexible tool that meets the increasing importance of data for healthcare. Its integrated marketplace provides one-stop access to a growing number of proprietary as well as curated and pre-vetted partner applications. Siemens Healthineers alone currently provides more than 40 apps, a third of which are AI-powered, for six different clinical specialties. This enables advanced and customized digitalization for a wide range of healthcare providers and care situations.

Digitalization is certainly not only a technological but also a conceptual issue. If medicine wants to harness the increasing abundance and complexity of health data – and this is precisely what is emerging – then this means a threefold paradigm change:

• First, as outlined above, healthcare providers need a digital infrastructure that is as simple as possible, yet versatile and adaptable, ideally in the form of a system-wide platform for networking data.

• Second, a steadily growing number of intelligent applications are needed that can meaningfully prepare networked data for specific operational and clinical questions. A number of relevant examples have already been illustrated here.

• Third, however, digitalization is also changing the very nature of medical decision-making itself. Medical decisions will continue to be the responsibility of doctors – and patients. Nevertheless, the individual human actors in the care process will increasingly have to make use of advanced digital decision support in order to bring the wealth of data into their deliberations and use it in a profitable way.

Medicine is not data science. But we believe that medicine in the future cannot do without a data science perspective. A flexible platform that is capable of integrating more and more data is vital here. Flexibility is the greatest asset in a digital world.

Naturally, transformative processes do not happen overnight. Siemens Healthineers' "teamplay digital health platform" takes this into account. It allows a quick start that does not require major investments and restructuring. Through an interoperable, system- and vendor-neutral design, the platform integrates existing and very different IT components and enables a step-by-step approach. Data silos do not need to disappear immediately (which is unrealistic), but can be tapped, and data treasures can be extracted bit by bit.

Moving toward smart data integration in medicine is thus a somewhat longer way forward. Holistic decision-making for the benefit of the patient is the rewarding goal.

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