Value-Added Process Design for Digital Transformation in Hospitals and Medical Networks

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1 General Thoughts

Today's health care is increasingly caught between financial resources, high service requirements, and continuously regulating quality levels in an increasingly professional and automated value-added process.

1.1 Clinical Data and Participations

First of all, a few basic thoughts on the structuring of digitally-supported medical care in the regional area are allowed. The development is moving towards a recognized center oriented according to competencies at a real and virtually networked location. This competence center will be an interface for referring physicians and care providers. It communicates values to be achieved together and makes joint progress visible by means of quality indicators. The basis of all actions and measures is a digital documentation and storage of medical information in a center, combined with direct but regulated access to existing data and examination results of defined partners. The outpatient and inpatient care system communicates via the same medium and integrates the patient as customer and "co-administrator" in the data exchange.

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1.2 The Partners and Their Particular Interests

The patient as a decisive and co-determining customer and owner of digital information is increasingly coming to the fore and has a greater say. The role of the competence center in (previously still called a hospital) is increasingly limited to that of a diagnostic and therapy initiating center. The referring physician in the form of an external clinic or practicing doctor or, in the future, also as an insurer (special individual treatment contracts) will become more important in his function and task. The insurer will be increasingly involved in the procedures and quality-forming processes as a financing and contractual partner. This is made possible by a digital platform that is enabled by IT providers in the form of network providers with management of data and access rights. With the IT provider, a professional group is created that works individually and highly specialized on the health care system with partners such as the practice/family doctor's practice, medical care centers, primary and maximum care clinics, and outpatient care services. What is new, however, is that patients themselves are increasingly transmitting data on health parameters and lifestyle, which, through artificial intelligence, enables a new form of diagnostics and therapy monitoring.

A further group is the pharmacy structure, which up to now has often operated independently, which is needed in the supply systems to ensure the provision of medical care in outpatient and sometimes remote rural areas.

Here, the field of activity of the pharmaceutical service must be redefined.

1.3 Current Digital Networks in Field Test

The Federal Republic of Germany has a very complex and decentralized medical care system. In contrast, Sweden, Great Britain, and Switzerland have more clearly definable care structures, which is why uniform digital networks entered the test phase years ago.

These networks are very complex and require not only uniform bases in data availability, uniform data protection and rules for the protection of personal rights. They also require a powerful data transfer and storage system that allows the implemented partners to access a form of a digital patient file at any time.

1.4 Devices for Digital Data Acquisition and Documentation

In the last 5 years, an astonishing number of digital measuring instruments have reached series production readiness in everyday clinical practice. Data acquisition and data networks in clinics and outpatient medical facilities are also increasingly gaining substantial improvements and a high proportion of data storage. For this reason, a whole new world of continuous recording of vital parameters and behavioral patterns in patients undergoing therapy and in follow-up care is opening up.

This includes completely new data platforms, which bring together measuring devices placed close to or on the body itself in their data acquisition and enable a profile of the activity and health status of a person without the data evaluator (doctor or nurse) having to be physically present. Not only tele-medicine with its possibilities for a virtual consultation hour but also the continuous recording and evaluation of vital parameters generates a completely new quality in medical care. Above all, this does not take place in short visits with monitoring breaks of days or weeks as in the past, but continuously online.

1.5 The Patient as Customer

By placing the patient at the center of future care networks and technical innovations, it will be possible for patients to receive medical care in less and less time. Thus, consultation hours with waiting times of several hours will soon be a thing of the past. In other words, a patient will no longer tolerate such time delays. The consultation and diagnostic interventions will be expected directly by the patient and will require consultation hours that will exceed the current regular working hours of the current outpatient clinic or consultation service.

Patients will increasingly question the quality of medical care, base their decision on the choice of physician on this, and external service providers will also advise them on which medical services offer the highest medical quality and safety for them as patients at that time.

Only facilities with high technical and qualitative standards and the ability to provide patients with data on demand will survive on the market in the future. The documentation on patients' own data carriers will quickly make redundant repetitive services transparent and easier to control not only for the patient but also for the cost unit. In the current insurance system in Germany, costs currently play only a limited role for the patient, as he or she is only rewarded to a limited extent for avoiding illness or avoiding therapy. But with digitization and the increasing number of treatment contracts and conditions offered by individual insurers, these aspects will nevertheless come to the fore in terms of health insurance contributions and the assumption of services by the insurer. In the future, the patient, as a customer, wants to be the focus of attention and be involved in the decision-making processes as to who will carry out which intervention, diagnosis, etc., when and where.

This is not contradictory to the fact that the patient nevertheless wants to be guided and advised directly, even in view of the large amount of data and the difficulty of getting the data right in detail, but can also be involved in decisions at any time.

2 Practical Examples

The above-mentioned fundamental considerations are now illustrated in the following examples, which are only exemplary and reflect only a small selection of the current developments.

They come from the field of geriatric medicine, which is particularly challenged by the complexity of multimorbid patients and their fragility and can particularly benefit from digitized structures.

In addition to the fact that there will be an increase in this patient group and its obligation to intervene and treat, the problem is also faced with a decreasing supply of care and physician density.

For this reason, care for this patient group in particular must be reconsidered and innovative trans-sectoral care networks must be created.

It is therefore assumed that this patient group is functionally limited, often disoriented and often unable to provide information about themselves in emergency situations.

Which constant, which reference points are then leading as parameters in the decision-making processes and lead to the triggering of courses of action and supply chains? If one translates the multimorbidity, which is complicated in this case, then one can compare the situation with a pilot in a cockpit under bad weather conditions during a landing approach.

Two basic groups with regard to decision-relevant data can be formulated.

1. surrogate parameters in the form of functionality recorded by a standardized, process-related clearly structured geriatric assessment, and a defined sensor system for recording vital parameters.
2. surrogate parameters in the form of quality-of-life states which are based on special assessments independent of the body condition parameters previously considered in medicine.

Diseases that are mostly chronic are thus brought into a new functional relationship with clinical parameters and known diagnoses that determine quality of life.

The 12 illnesses that exist on average in an 85-year-old person are summarized in the so-called geriatric syndromes and transferred into logical relationships. This is currently still done according to medical experience and following medical guidelines for defined individual diseases (Schulz 2012).

The emphasis here is on “still,” since there is an increase in artificial intelligence (AI) supported diagnostics.

This clinical situation requires a maximum of prioritization of the problems taking into account the organic and functional reserves. The multitude of data and clinical correlations must be evaluated visibly but also in terms of quality of life in an overall perspective.

Multimorbidity thus means that it often results in multiple medication, which requires multiple interactions and intolerances to be taken into account.

The fact of multimorbidity, however, also means that multi-organ insufficiencies in a labile equilibrium have to be considered simultaneously during therapy.

The result of these considerations is therefore the question when is or becomes which parameter leading and decides on further diagnostics and therapeutic measures?

When in which period of time is which functional or organ-dependent problem so dominant that it endangers the goal of a good quality of life and results in a continuous high need for care? (Rummer and Schulz 2012).

Which factors are first or second order preventive relevant with regard to complications, hospital admissions, and avoidance of permanent inpatient nursing care.

The decision for the choice of specific therapy concepts depends on data from digital networks at the time of geriatric therapy, the joint therapy of patients with outpatient physicians and the geriatric care options.

At present, valuable human resources are being consumed for data collection in the absence of existing data storage facilities. There is also the additional disadvantage that there is a high risk of errors in the collection of information. Likewise, everyday life is made more difficult by incomplete documentation due to lack of personnel, limited time resources, and different documentation media.

The goal must be to obtain medical and biometric data digitally in real time and to integrate them into result-oriented learning intervention models with the support of artificial intelligence.

The question is therefore how can digital data be prepared and supported in the future so that the scarce personnel and time resources can be used as effectively as possible?

At the St. Marien-Hospital in Cologne (Germany), a unit for cognitive insufficiency has been investigating for several years in a kind of space lab situation the obligation to document new parameters in patients suffering from dementia who are unable to provide information. Under the realization that currently this cognitive impairment cannot be significantly improved by drug interventions, new concepts for the therapy of the emotional peculiarities of the disease are being investigated. In contrast to intensive care units, where patient data are connected to a monitoring system through body-fixed electrodes, this is not possible with patients who are often very mobile. For this reason, new approaches to WLAN-based sensor technology are being tested.

Therapeutic concepts instead of drug interventions can be realized, for example, by means of novel architectural structures of a hospital unit and the resulting positive changes are documented. These findings, in turn, will then be integrated into the special and individual design of the personal domestic environment.

This experimental building structure is clearly structured, structured with defined color accents, takes haptic and visual stimuli into account, such as haptically distinctive wallpaper, certain surface structures on the walls and the so-called *Snooze units*.

But new elements such as a humanoid robot can also be used for emotional therapy approaches.

For the hospital of the future, special rooms are being tested for a special sensor technology to accompany emotional activity states, which will enable room monitoring with regard to movement, patient activity patterns, air quality, temperature, and noise development.

Especially the continuous documentation of the sleep rhythm and other activity patterns allow important conclusions to be drawn about drug therapies. The dosage for very elderly patients with organ insufficiency is often imprecise and only very roughly possible. Especially the digital feedback on therapies with psychotropic drugs seems to be very promising in terms of avoiding complications with prolonged hospital stays. Currently, there is no system that adequately supports this complexity in the form of digital medical interventions supported by sensor technology and artificial intelligence.

One example for the use of smart material.

The VulnusMON project, funded by the Federal Ministry of Education and Research of the Federal Republic of Germany, attempts to identify intelligently selected monitoring parameters of body states without a great deal of personnel effort. The aim is to develop a wound plaster that records wound conditions in terms of moisture, body temperature, and other parameters in real time and to transfer the data into a digital care network. This would mean that less care effort with less manipulation of the wound would be an important parameter.

The time required to treat the wound should be more targeted. But also the now required documentation effort could be reduced significantly. Also the error rate of not being able to treat wounds at the decisive moment for therapy should be reduced. The wound cannot be continuously monitored for healing in the currently existing treatment concepts. It is also being tested how a wound care network can be formed around this digital wound plaster. This includes surgeons, general practitioners, outpatient nursing services, and other specialists such as wound dressing manufacturers. All these partners need to be provided with data that they must receive in real time and be able to plan their interventions accordingly.

The already mentioned technology concerning a simple ceiling sensor system in a room with monitoring of the activities of patients under psychotropic drug therapy is investigated in the experimental approach “Technology and Analytics.” The imaging of drug effects and side effects in real time can be a great opportunity for cognitively impaired patients. Avoiding overdosage saves large diagnostic loops with a very complex differential diagnostic checklist. In addition, such systems can be expected to avoid the number of falls with life-threatening fractures and intracranial bleeding. An essential therapeutic approach from the above-mentioned circadian room lighting is documented by such ceiling sensors with documentation of a resolved day-night rhythm and corresponding sleep disorders. In other words, it is possible to detect with appropriate sensor technology how, for example, a disturbed sleep rhythm can lead to concentration disorders and depression. Due to low structural and constructional effort it will soon be possible to monitor rooms in which patients are staying in stationary care facilities and hospitals but especially in the home environment. Especially for the home environment, this promises to maintain a high quality of life by keeping the patients in their own rooms.

A further therapeutic application is the digital control of light scenarios that are subject to the bio-rhythm with the maintenance of a corresponding metabolic rhythm. The digital control of light in rooms for conditions similar to daylight. This is not only possible in defined hospital rooms, but is already being introduced into the everyday life of private users and their living environment.

It has been scientifically proven that this leads to an improvement in emotional stability. The aim of the project at St. Marien-Hospital is to document the reduced psychotropic drug dose in patients. Also the avoidance of liberty-taking measures for the protection of patients is the goal of this digital light control and composition of light frequencies and their intensity.

Among other things, the human bio-rhythm is subject to two already well-studied bodies own hormones. Namely the cortisol level and the melatonin level. Both hormones control the sleep behavior and metabolic activity and thus the mental activity of every human being.

All these considerations are currently being evaluated internationally in digital assessments. These assessments ask for the so-called prognostically relevant, functional and laboratory medical parameters which are summarized in a so-called Multi Prognostic Index (MPI).

These parameters do not necessarily have to be recorded by medical personnel, but can also be determined by *Artificial Cognitive Systems*.

For example, we are currently investigating to what extent humanoid robots can not only improve the emotional state through standardized interaction and entertainment programs, but can also document parameters such as temperature and pulse via appropriate camera systems in addition to recording the emotional state by means of facial mimic analysis. The goal is to record actions and reactions in connection with patients free of human judgements and evaluations.

These parameters can not only influence therapy concepts significantly in the future, but also determine the degree of care required in further patient management. Not only the pure functional possibilities of the patients and abilities supported by aids are included in the analysis, but also the co-factors in the home environment that determine the quality of life. These quality-of-life factors must be recorded in new types of assessments, documented digitally in patient-related media, and communicated to the care networks. New parameters have recently been published for this purpose (Bordne et al. 2020).

The documentation and digital storage of subjectively perceived quality of life improvements and the associated interventions point to the new development according to which very old patients evaluate their satisfaction with medical care, nursing care, and social ties. The realization that functional improvement does not necessarily improve the quality of life has not yet been taken into account in the considerations that determine therapy. Unfortunately, however, it is also so complex that it will only be possible to store certain “patterns” in patients’ own documentation media and integrate them for further concepts.

The 360° overall concept from hospital care to home care with as preventive an intervention as possible is the future. These concepts are only possible through

digital care networks and will be able to meet the demand for real-time interpretation of health changes and biometric parameters.

3 Conclusion

The conclusion to be drawn from the above-mentioned examples is that IT platforms are the key to an effective care network. These networks, as they are being tested, for example, in Sweden, Switzerland, Great Britain, and other countries like Denmark, have a future. Artificial intelligence can support decision-making processes in the collection and direction of data and, in the best case, prevent patients from having to be regularly transferred to inpatient care facilities (Rummer and Schulz 2012). However, it is essential that the hospital architecture and room conditions adapt quickly. In the next decade, *Future Hospital 4.0* will have to combine biometric and laboratory chemical parameters in real time without great technical effort and support the interpretation of disease states during medical visits.

Data protection must be improved for these care networks and ensure that this data is only compiled and stored at the patient's location. The current interweaving of medical topics and consumer-dependent parameters does not necessarily have to be a disadvantage, but it does lead to considerable data protection and legal problems. It is clear, however, that the definition of medical parameters and consumer-related parameters are difficult to separate from each other and can be used in the future in a supportive manner, such as movement profiles, intensity patterns with regard to certain topics, areas, etc. The question remains to what extent and to what depth supply networks can be supported or coordinated by artificial intelligence.

There is currently no lack of technical innovations in data management and networking. The advantages, such as increased patient well-being, improved quality of diagnosis and treatment, and reduced medication errors, are convincing and will significantly support future digital documentation and sensor technology. However, further research is needed to combine data quality with higher data security.

Facilitating communication between healthcare providers and, above all, in remote, decentral coordinated communities is a particular challenge. It becomes clear that due to the lack of qualified nurses and physicians, the adoption of redundant data acquisition using sensor technology and artificial intelligence represents a great opportunity for the healthcare system of tomorrow. Parameters such as body temperature, weight, recording of medication intake and its immediate effect profile, but also the recording of over- and under-dosage, the care and playful recording of emotional states and thus quality-of-life parameters will have a decisive influence on the future with regard to the amount of care required and the satisfaction of a health care system. The evaluation of image material and biographical data play a special role, especially for multimorbid very elderly patients, and form a special focus of the project.

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