

Whitepaper

How can a digital operating room bring value into the complex hospital setting?



AUTHORS

SKC Beratungsgesellschaft mbH
Pelikanplatz 21
30177 Hannover
Tel. +49 511/ 6468 14 – 0

Nina Rüdemann, Maximilian Florian, Prof. Dr. med. Matthias Schönermark, Heike Kielhorn-Schönermark

© Copyright 2020, SKC Beratungsgesellschaft mbH

All rights reserved.

The content of the white paper is subject to copyright. Distribution, quotations, changes, and duplications – even in the form of extracts – for third parties is only permitted upon prior written consent of SKC Beratungsgesellschaft mbH (SKC).

Any reproduction is only permitted for personal use and only under the condition that this copyright notice is retained on the document itself when it is reproduced.

A project in cooperation with  **BRAINLAB**.

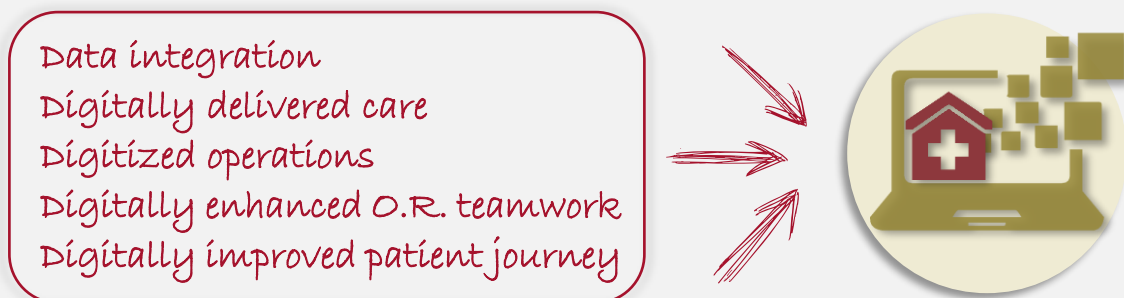
Content

EXECUTIVE SUMMARY	4
1 INTRODUCTION AND PROJECT BACKGROUND.....	5
1.1 DESCRIPTION OF THE KEY QUESTION AND RESEARCH METHOD OF THE SURVEY	5
1.2 BACKGROUND: MAJOR CONSTRAINTS AND CHALLENGES FOR HOSPITALS TO ADOPT TO THE DIGITAL SHIFT	5
2 HIGH-LEVEL STUDY RESULTS: WHAT DO HOSPITALS WANT IN TERMS OF DIGITIZATION? – THE DIGITAL VALUE GENERATION MODEL.....	6
3 THE DIGITAL VALUE GENERATION MODEL’S FIRST LAYER: “DIGITAL GOALS”	7
4 THE DIGITAL VALUE GENERATION MODEL’S SECOND LAYER: FIVE “VALUE GENERATION LEVERS” OF DIGITIZATION IN THE O.R. AND THEIR VALUE POTENTIAL FOR HOSPITALS.....	7
4.1 DATA INTEGRATION – FOCUS ON SYSTEM-WIDE DATA: INTEROPERABILITY, SCALABILITY, PRODUCTIVITY AND FLEXIBILITY.....	8
4.2 DIGITALLY DELIVERED CARE – REDEFINED CARE DELIVERY FOR THE WHOLE PATIENT JOURNEY	9
4.3 DIGITIZED OPERATIONS – OPERATIONAL EFFICIENCIES THROUGH TECHNOLOGY	10
4.4 DIGITALLY ENHANCED O.R. TEAMWORK – ALLOW CAREGIVERS TO SPEND MORE TIME PROVIDING EXCELLENT CARE WITH IMPROVED COLLABORATION AND LEARNING	11
4.5 DIGITALLY IMPROVED PATIENT JOURNEY – ENABLE SEAMLESS PROCESSES TO DIGITALLY IMPROVE PATIENT EXPERIENCE.....	12
5 THE DIGITAL VALUE GENERATION MODEL’S THIRD LAYER: REQUIRED “ORGANIZATIONAL CAPABILITIES” ...	13
6 CONCLUSION	14

Executive Summary

A project carried out in collaboration between the SKC Consulting Company and Brainlab investigated how a digital O.R. could affect the economic and medical performance of hospitals' operating rooms as well as which prerequisites and success factors enable hospitals to explore promised digitization potentials. As a result, a Value Generation Model of digitization in hospitals has been developed, revealing the most important goals for using a digital O.R., five central value generation levels of digitization and required organizational capabilities.

Hospital goals drive investments in digitization, with a top priority laying on reduced bureaucracy efforts and perfectly coordinated processes for time savings and higher treatment quality. Additionally, the research has proven that the five value generation levels as essential focus application areas of digitization are crucial for unveiling the relevance and hidden potentials.



Data integration as the first value generation lever enables hospitals to enhance flexibility, interoperability, scalability, and productivity for seamless workflows by consistently capturing, storing, securing, sharing, and merging all patient relevant data. As a result, the way is paved for the second value generation lever - a more and more digitally delivered medical care, enabling medicine to become more predictive, personalized, and precise through novel targeted care support, such as AI and Big Data. The third level is about digitizing operations, seen as an opportunity to exploit efficiency potentials, especially by simplifying burdensome supporting processes and integrating data into one digital operating room system. Fourthly, digitization allows for the optimizing of O.R. teamwork and knowledge sharing by facilitated collaboration and learning possibilities through the power of digital software tools and remote consultations. Bridging these four levers, digitization adds value to the entire patient journey, thus smoothly improving the overall experience and addressing the highly individual needs of the patient.

In order to meet the goals for setting up a digital O.R., all value levers must be met. But it is only possible to implement the value levers if the hospital develops its organizational capabilities: a long-term infrastructural and processual alignment towards digitization which requires secured economic funding. Together with comprehensive digital empowerment of the hospital's stakeholders, profound training, and an early risk management accompanied by cyber security measures, these organizational capabilities are identified as important success factors. At the same time, they fulfill the prerequisites for a successful digitization process in the O.R., altogether securing the delivery of futureproof medical care in hospitals.

1 Introduction and project background

1.1 Description of the key question and research method of the survey



Key question:

The conducted project pursued the key question **“How can a digital operating room bring value into the complex clinical setting?”**, and thus paves the way towards an adapted perspective on digitization – away from the digital technology provider’s point of view towards the “users” perspective of inpatient medical care technology. The target of the investigation was to develop a profound understanding of the status quo, which involves the inpatient workflows as well as hospitals’ challenges, demands and attitudes regarding digitization, especially in the operating room. On this basis, the values of digital O.R. solutions were explored from a customer’s perspective.



Method of survey and presentation of results:

The key question was investigated applying the value proposition design methodology with a value mapping originating from a user’s perspective. This approach led to the conduction of expert interviews and observations in the real clinical setting. Thus, as a method of assessment, 21 qualitative explorative expert interviews, including observations of real-life surgeries and examination of complete O.R. infrastructures, were carried out. The inquiries took place in the first quarter of 2020 in several maximum and regional care hospitals around Europe (i.e. in Germany, the Netherlands and Sweden). In this context, the perceptions of various hospital stakeholder groups were incorporated either already working in a digital operating room environment or not yet. Interviewees included surgeons of different medical disciplines, surgical nurses, technicians in strategic and operational positions and members of the hospital management, such as CEOs and O.R. managers. The interview findings were cumulated per stakeholder group, resulting in four superordinate customer groups:



Surgeons



O.R. team



Technicians



Management

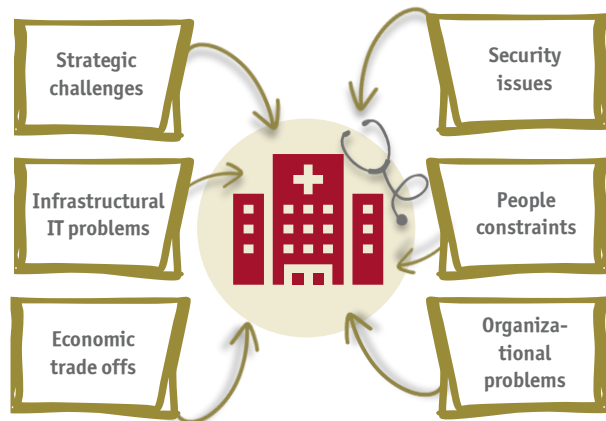
The surveyed data and findings will be outlined in the following chapters, both at an aggregated level and at a

customer group-specific level, with real interview quotations providing a realistic scenario of different hospitals’ market conditions and expectations regarding digitization in the operating room. As a result, a value model has been developed from a hospital’s perspective, including the most important goals, digital value generation levers and required organizational capabilities for digitization. The “lessons learned” and resulting implications for value driving digital O.R. solutions will be described in detail below.

1.2 Background: Major constraints and challenges for hospitals to adopt to the digital shift

Exogenous and endogenous forces:

Hospitals face different challenges and dilemmas when deciding about digital solutions. These exogenous and endogenous forces majorly impact hospitals’ processes and include the following components:



Currently, the main reasons for a decelerated pace of IT penetration are: insufficient investment financing, the lack of a comprehensive digital strategy, data protection debates on cyber security, incompatible software solutions, deficient personnel empowerment, and employees’ concern of a temporarily increased burden associated with the introduction of new digital systems. [1] Hence, the inpatient system is a double-edged sword, constantly balancing on the sharp blade between high-quality, state-of-the-art medical care and massive economic pressure.

Especially in the context of demographic changes and an increasing shortage of medical and nursing staff, the introduction of digital innovation becomes more and more important. The economic pressure weighing on the inpatient system emerges in the heightened probability

of financial failure in European hospitals, amounting to an average of 50 percent and induced by accumulative annual financial losses. [2] In several European countries, the hospital sector records significant investment gaps up to € 4.5 billion per year, exposing the lack of public investment funding, money urgently needed for digitization measures. [3][4] As most hospitals lack adequate financial resources for the digital transformation, the infrastructure becomes more and more outdated. A study on the Electronic Medical Record Adoption Model (EMRAM), a score categorizing hospitals based on their digitization degree from zero (no digitization) to seven (highest possible digitization, paperless clinics), shows that the European average digitization level is merely at a score of 3.6. [1][5] The digital transformation in medicine has already shaken numerous traditional paradigms - be it the clinical diagnosis through Artificial Intelligence (AI) support or Big Data during surgery - leading to the challenging

requirement for hospitals to develop concrete digital strategies. [6] However, 83 percent of hospital managers describe maturity and quality of in-house digitization as insufficient, especially calling for universal data standards and pointing out the low compatibility of IT-systems, as well as the absence of a proper digitization strategy for their hospital. [7] With that being said, significant potentials can be derived in the area of digitization in the hospital sector which, in the end, is elementary for more efficient processes, improved networking between the care sectors, and high-quality, needs-based medical care.

91 percent of all hospitals invest less than 2 percent of their total expenditure on IT measures. [8]



2 High-level study results: What do hospitals want in terms of digitization? – The Digital Value Generation Model

Overall, the interview findings result in a Digital Value Generation Model, consisting of three layers, for comprehensive and long-term value creation in hospitals through digitization.



The first layer is illustrated as the model's inner circle. It relates to the identified digital **goals** which represent the overarching value creating dimensions for hospitals and help to achieve the best possible treatment for the patient. For details, see chapter 3.



The second layer is visualized as the middle circle and defines five substantial **value generation levers of digitization**, providing profound insights into the most important focus application areas of digitization. For details, see chapter 4.



The third layer, depicted as the outer circle, pertains to hospitals' **organizational capabilities** which are required prerequisites for a successful implementation of solutions digitizing the O.R. For details, see chapter 5.

3 The Digital Value Generation Model’s first layer: “Digital Goals”



Background: The users’ understanding of digitization:

In order to determine the specific requirements a digitized O.R. system ought to meet, which lead to the five digital value generation levers, it is first essential to explore what the different hospitals’ parties understand by digitization in the operating room. The survey results show a rather uniform depiction. Users across all groups perceive the operating room as one coherent system and do not distinguish between technical hardware, software, and medical devices. They expect digital solutions to affiliate, simplify and fasten the workflows connected to the operating room.

Why implementing a Digital O.R.?

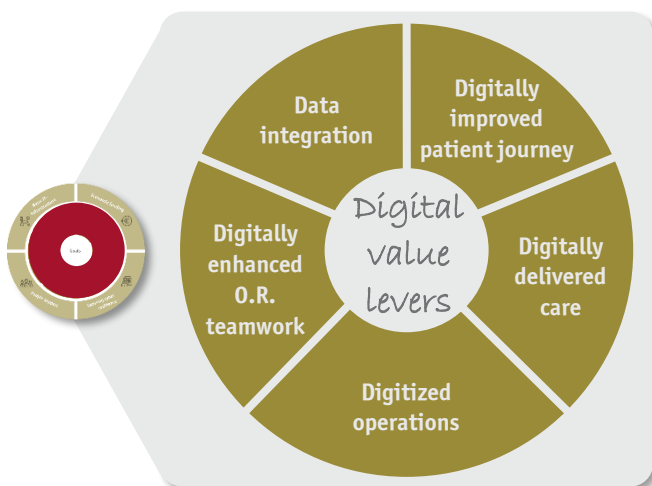
Hence, the relating goals of digitized O.R. solutions do not just refer to one single key parameter, but rather to a variety of different factors impacting a hospital’s efficiency. Pooled on a detailed level, the goals of reduced bureaucracy (e.g. less searching and documentation efforts), smooth workflows (e.g. shorter O.R. changing times, reduction of waiting times), increased economic value (e.g. more surgeries per day, savings in intensive care times, more complex surgeries) and enhanced medical care quality (e.g. reduced infection risk, lower rate of complications and second

interventions) are of fundamental importance for the different interviewed parties. Cumulating the interview results on a high-level perspective, the six overarching goals - quality, safety, efficiency, waste reduction, speed and proficiency - are the most relevant for the interviewees and thus, bring the highest value for a hospital’s viability.



Consequently, these goals form the basis for hospitals’ investments in digitization. But what does this mean at the product level of the digital operating room? Which concrete subject areas should digital O.R. systems encompass? The interviews and observations revealed five major value generation levers of digitization as important areas of interest.

4 The Digital Value Generation Model’s second layer: Five “Value Generation Levers” of digitization in the O.R. and their value potential for hospitals



The application areas of digitization in operating rooms are key future drivers and refer to the structural, processual and outcome level in terms of preparation and planning, diagnostics and therapy, documentation and monitoring. The interviews and observations have shown that current digital O.R. solutions already create synergies in these areas. However, hospitals currently lack suitable concepts for performance measurement of digitization. Few studies give rough indications for reduced personnel costs and processual time savings (see chapter 4.1 to 4.5). Nevertheless, **beyond the individual perspective, the interview partners have shared their opinion on general digital value generation levers in the O.R., aggregating the key learnings of this study.** The five value levers are closely intertwined and have the potential to comprehensively enhance hospital performance by addressing the six overarching goals.

4.1 Data integration - Focus on system-wide data: interoperability, scalability, productivity and flexibility

Relevance of the lever:

We are living in an age of data that seems confusingly complex. The period in which knowledge doubles is getting shorter and shorter and proliferates in high speed.



Solely in the medical field, the amount of available data doubles every 73 days in 2020. [9]



In 1950, the time it took for data to double was 50 years. In 2010, this period was reduced to 3.5 years. [9] The highest efficiency potentials lie in the fields of paperless data, digital decision support through performance dashboards and automation of workflows. As explored by studies on the U.S. and German healthcare markets, up to \$ 23 billion and € 16 billion in savings could be realized by hospitals through digitization, especially by optimizing supply chain operations and process flows, i.e. with a structured data transfer, remote monitoring of patients, dashboards accessing uniform data bases, digitally enhanced staff communication and data-driven patient flows. [7] [10] But this integrated use of data will only happen if the data is systematically available. Hence, the first value generation lever that supports to attain higher productivity and financial savings in hospitals is the complete integration and management of data, influencing all processes and spanning the other value generation levers.



Survey findings:

The interview results show that one major challenge for hospitals in terms of data integration is the lacking **compatibility** of already implemented IT systems and thus, a rising susceptibility. Several IT systems and medical devices from different providers with limited **interoperability** are usually operated within the clinic. Oftentimes, specialized **isolated solutions** for the Electronic Health Record, workflow and documentation support, and radiological image storage **are already implemented**, handling data in a separate way and

resulting in prolonged implementation phases of new software. A lack of system integration frequently induces a rising complexity, more interfaces, different data formats and undesired interactions between various hard- and software solutions. **As a result, the need for a digital O.R. system that integrates all data, especially into one user interface, is rated as increasingly important.**



"Data processing invisibly running in the background on a central server connects the entire operating area rather than just one single O.R. "

The interview results highlight interoperability, scalability, productivity and flexibility as the essential requirements for data integration. In this context, it is assessed as highly relevant that digital O.R. solutions integrate seamlessly into the already implemented IT systems and meet up-to-date, universal and futureproof data standards. The interviewees emphasized the importance of targeted data integration according to the uniform standards HL7/ FHIR, DICOM and Open EHR. Thus, hospitals can ensure **flexibility** with the possibility to adapt to the possible future developments and innovations in healthcare. In the interviewees' perspective, the system-wide capturing, storing, securing, sharing and merging of all patient relevant data in a digital format for seamless workflows is seen as a major value.

Example: The constant synchronization of data on a single, easy to use and intuitive digital platform with one interface could reduce time and efforts of manual data searching and data reconciliation.



"The more easily information is accessible, the more efficiently work can be done."

According to the interviewees', data integration also relates to increased data storage demands and costs due to rising data volumes and improvements in the resolution of medical imaging data, which often cannot be met by the local storage capacities of medical devices. Consequently, the interviewed hospitals are gradually replacing conventional storage methods by flexible, device-independent concepts including central servers within the hospital network, and additional cloud storing options, increasing the flexibility and **efficiency of data access** at the same time. Nevertheless, the interviewed hospitals expressed concerns about the data safety of cloud computing solutions and associated increased data security requirements. However, central data storage options are rated as the foundation for an intelligent cross-linkage of the whole hospital's IT system and is thus assessed as an important driver for interoperability.

4.2 Digitally delivered care - Redefined care delivery for the whole patient journey

Relevance of the lever:

The continuously growing amount of medical data evokes the second value generation lever of digitization – a paradigm shift towards a more and more digitally delivered medical care. Big Data and Artificial Intelligence are the main drivers for a more accurate **prediction** and **personalization** in medicine. Artificial Intelligence is believed to have great potential by collecting patient data in a “collective memory” and evaluating it with common data models to develop algorithms for enhanced diagnosis and ultimately provide the best possible medical treatment. [11]

With an ever-increasing amount of data being produced in a hospital, it is important to be able to structure, analyze and access the data in a systematic way to improve the treatment of patients and realize financial savings. [12] Recent studies suggest that up to one fifth of healthcare expenditures are spent on duplicate and uncoordinated medical care delivery. In this regard, patients are facing dispensable bureaucracy with 60 percent of them repeatedly taking the same medical tests, and 74 percent providing the same medical information to several healthcare professionals – an issue that can be streamlined through digitally coordinated data. [13][14] In general, 90 percent of doctors evaluate digitization as a great opportunity for the healthcare system and hospitals, while 64 percent of hospitals’ managers are convinced that Artificial Intelligence will fundamentally change the healthcare system. [15] With the aid of case-specific, pre-surgical planning tools, predictive modelling, navigation and decision support during surgery, the era of **precision medicine** gradually finds its way into all surgical routines.



Survey findings:

The interviewees emphasized the importance of **structured data collection, processing and analyzing** as this opens the possibility to identify hidden patterns and correlations in order to support medical decision making. Hence, data-based computer algorithms are identified as possible helpful tools to increase verified and precise treatment decisions based on AI solutions that should be

subject to constant further developments. As effects on the outcome and quality of care are evaluated as multidimensional and difficult to measure, the further evolution of Big Data is expected to improve medical predictability. Highlighted by the interviewees, one **value of digital solutions is in the pre-surgical planning**, as patient information could be enriched for specific indications with predictive modelling and imaging in order to generate personalized risk forecasting and therapies.

Example: With implemented planning software tools, regions of interest can be precisely depicted within the 3D patient DICOM images prior to surgery, creating an individualized surgical plan. During surgery, **software solutions allowing for the editing of plans and including Artificial Intelligence for decision-making support are assessed as highly valuable by surgeons**, e.g. for easy recognition of differences in the tissue structure or the precise depiction of the patient’s anatomy. Postoperatively, digitally delivered care could support the patient monitoring process.



“The better I can visualize the anatomical facts, the better I can understand the individual case.”

Additionally, the survey results indicate a continuous need for advanced data integration throughout the entire surgical process, for example the availability of medical and imaging data in the operating room. One of the key findings of the survey discloses how AI can provide support during surgery. While most simple standard procedures are conducted without precise planning and decision support, complex and demanding surgeries could profit from AI treatment suggestions.

Precise planning and optimal visualization of the surgical field with enriched pre- and intra-surgical imaging data are assessed as essential prerequisites for complex procedures. With software support on the basis of Big Data and AI, in combination with suitable medical equipment, the interviewees hope to achieve better surgical outcomes, decreased complication rates, avoidance of second interventions and consequently, a higher patient satisfaction and safety. Also, a differentiation between medical disciplines and surgical procedures is rated as indispensable for reliable and accepted AI solutions and constant improvements in the digital system development.

4.3 Digitized operations - Operational efficiencies through technology

Relevance of the lever:

The O.R. is a critical point regarding the organization of working processes and cross-professional cooperation in hospitals - for example between the wards and the O.R. team or within the clinical O.R. team. In order to ensure high **efficiency** in the operating room, it is important to optimally coordinate the four dimensions of space, time, personnel and material.



A digital O.R. is estimated to reduce the personnel expenditures between 10 to 38 percent compared to the traditional O.R. [16]

Currently, digital O.R. solutions primarily focus on higher workflow efficiencies regarding the reduction of:

1. risk sensitive events (RSEs),
2. data retrieval efforts,
3. documentation times.



1. On average, 15,5 RSEs are registered per surgery, thereof approx. $\frac{1}{4}$ are device related RSEs (e.g. device not turned on or incorrect setting). [17] An integrated O.R. with a **digital checklist** provides the capability of reducing device related RSEs by 65 percent. Other studies indicate that the cutting-suture time can be reduced by a digitized O.R. due to less time efforts in manual positioning, device setup and synchronization of the systems. [18][19] 2. Easily accessible in the operating room, **the instant availability of imaging data** can serve as a guidance for the surgeon during the procedure for increased patient safety. [20] 3. Administrative costs, including high documentation efforts, internationally account for 12 to 25 percent of total hospitals' expenditures, problematic particularly against the background of an escalating personnel shortage and increasing workload. [21] By 2030, the World Health Organization estimates a personnel shortage up to globally 9.9 million physicians, nurses and midwives – time spend on documentation processes will thus be lacking elsewhere for high-quality medical care. [22]



Surgeons spend an average of 4 hours and nurses a total of 3 hours per day on documentation, accounting for 21 percent of personnel costs. [23]



Survey:

The survey results show that a growing number of media disruptions, interfaces, isolated digital solutions and a higher rate of user errors currently impedes the seamless surgical flow. In the O.R., the interviewees are facing an increasing complexity of different medical devices and software, as well as high administrative efforts, while oftentimes being held responsible for surgical postponements and overtimes. This notably applies to the time-consuming documentation issues about surgeries, a bureaucratic obstacle with high risk of boosting the team's frustration. Poorly coordinated processes and missing data integration oftentimes triggers inefficiencies and duplication of work for the hospital's employees, especially in double analog and digital data logging, e.g. of used material and surgical times. Hence, the interviewed parties wish for a digitized O.R. system that not only integrates but also fully automates all patient-, personnel-, documentation- and equipment-related processes, as the greatest efficiency potentials are expected in these areas. The interviewees identified that a digital O.R. solution helps to simplify the supporting processes with a **standardized data handling, e.g. by an automated central storing, and a fast data transfer**, allowing caregivers to spend more time providing excellent care. Furthermore, **checklists, pre-configurations and the full availability of imaging data** are judged as extremely important requirements for digital O.R. solutions.



"Documentation is one of the most annoying topics when you actually want to treat a patient."

Example: An automated documentation of the surgery with a simplified data retrieval, i.e. by recording video sequences and taking snapshots of video data intraoperatively, could enhance the obligated written surgical report to verify the treatment outcome and to reduce the risks of accounting audits.

Digital technologies are rated as a chance to foster productivity and enhance job satisfaction due to the focus on more patient-centered activities. As every little mistake in the operating room could lead to potentially life-threatening consequences, a holistic and smooth system integration with one central data platform is required. Thus, a mandatory requirement of users for such a digital operating room is that the technology works impeccably and eases their daily work to realize efficiency potentials. In a nutshell, the interviewees highly embrace the idea of a **single data platform for the O.R.**, simultaneously enabling **data retrieval, visualization as well as documentation.**



"It would be perfect if all data could be called up via the in-wall monitor and if one could then also document on the device."

4.4 Digitally enhanced O.R. teamwork - Allow caregivers to spend more time providing excellent care with improved collaboration and learning

Relevance of the lever:

The fourth value generation lever refers to the **optimization of the O.R. teamwork**, a decisive factor for successful procedures since approximately 40 percent of surgical adverse events can be traced back to communication errors and knowledge gaps between the different O.R. team members. [24] Digitized O.R. solutions are believed to unfold the massive power of bridging the divergent skill levels between medical and non-medical staff, but also between skilled, experienced and assistant surgeons.

Digital learning platforms, online studies, home office, live streaming of events and remote consultation have already been established in diverse industrial sectors for years. The advantages of digital remote technology especially become evident when the outside environment changes in exponential speed as a consequence of sudden shifts in the market. Digitally well positioned and thus flexible organizations face less restrictions due to modern possibilities of **remote servicing, remote consultation and remote teamwork with streaming and video conferencing**.



A further study discovered that communication errors are responsible for approximately 4 RSEs per surgery and can be reduced three-fold by using structured digital support for the team time-out before surgery. [25] In this context the timing of the team briefing is crucial. Beyond that, modern O.R.'s might lower the physical stress level of surgeons operating in a modern operating room compared to a conventional O.R. due to better ergonomics. However, technical and device-related problems might contribute to an increased stress level in the O.R. as technical problems, team factors and device problems were the most common reasons for the current high stress that surgeons feel. [26] Digitized O.R. systems can solve these problems by providing integrated solutions and dedicated digital tools, e.g. checklists for team-timeout with full team visibility, to ease some of the major surgical stressors.

Survey:

The survey results reveal that a digital O.R. system paves the way to a new era of proficiency support by enabling **instant expert opinions** during surgery and by **empowering junior physicians** to perform more complex surgeries on the basis of precise pre-planned imaging data prepared by a senior physician in advance. The interviewed parties working in a digital O.R. identified significant benefits in the areas of flexible streaming possibilities and real-time remote consultation to align on tasks and responsibilities and to directly obtain medical expert opinions from outside the operating room.

Example: As these technologies can bring together people with different skill and qualification levels, **medical knowledge can consistently flow in and out of the O.R.** with the delivery of optimal patient centered care. Junior physicians and medical students also have the opportunity to learn directly from medical experts.

Furthermore, in the interviewed surgeons' perspective, surgical imaging cockpits that display instant imaging data and which are operable through touchscreen control, enable **situation-specific and intelligent support** with better ergonomics for surgery. Video routing allows for the surgical field to be displayed on multiple displays in the O.R. so that the entire O.R. team can stay on track, reacting quickly when needed, without crowding the surgeon.



"The video routing is the only way to follow what is seen in the operating room without having to dislocate oneself when looking at the screen on the microscope."

Pointed out by the interviewed technicians, the future is especially seen in **dynamic networking and system integration in open modular systems**, interoperable with already implemented IT solutions and tailored to the individual hospital's needs. However, one major restriction to completely unlock the digital potentials is seen in varying levels of knowledge about the full possibilities of implemented digital solutions. The widespread feedback of different hospitals indicates that a digital functionality is often implemented by technical departments, but the final users lack knowledge of the availability and the specific use of these features.

4.5 Digitally improved patient journey - Enable seamless processes to digitally improve patient experience

Relevance of the lever:

The fifth value generation lever of digitization pertains to the overall experience of the patient journey and refers to the entire patient data flow throughout. Hence, this last lever brings together the digital components and data requirements of the other four levers towards the benefit of the patient. When unstructured data such as pathology, blood tests and images, available from the hospital's pre-, intra- and post-surgical processes, is brought together to be **structured, analyzed and centrally stored over time in the patient's EHR**, a **digital twin, or a virtual model, of the patient** can be created. This data twin allows for the streamlining and further digitization of workflow processes throughout the entire patient journey as well as being able to guide medical professionals in their decision making to ultimately provide the patient with the best treatment possible and improve patient satisfaction holistically.



In the hospital setting, patients especially identify great potential for improvements in adequate communication, organizational processes (= process quality leading to reduction of delays) and the coordination between different clinics and care sectors (especially the transition from inpatient to outpatient care and nursing homes). [27]

Survey:

According to the interviewees, the ideal patient journey supported by digital O.R. solutions begins with the smooth admission of a patient and ends with a fluent discharge process. In the optimal scenario, new data is constantly collected coming together in one digital platform to form the patient's digital image, the personalized digital twin. The most important aspects throughout the entire patient journey are outlined below.

“Every inpatient case is different! But in the end, if you break it down, our most important job is to save lives and make the patient feel at ease.”



- Right from the start, the admission process time is reduced with digitalized and simplified check-in forms. With the **integration and synchronization of a patient's history** into one source, the information necessary to complete the form is minimal (i.e. past medical history) and time spent on such forms is decreased.
- The digitally structured patient data, together with specific AI & Big Data analyses, takes a large amount

of guesswork out of the pre-planning stages. By overlaying statistical information with the **personalized data, customized treatment plans** become easily visible. The patient benefits from an individualized treatment approach which minimizes the potential negative outcomes like adverse events.



- With the help of **digital visualization tools displaying medical imaging data**, such as mixed reality, the patients can see their medical data as a more tangible object. The surgeon can then guide the patient through the planned procedure, enhancing the patient's understanding, building trust and answering outstanding questions or concerns.
- In the O.R., the **procedure can be started “just-in-time”** with the automatic prefetching of data. All relevant data of the patient, merged as the digital twin, is available during surgery alongside the real-time viewing of the procedure and the patient's vital parameters so that the entire O.R. team can anticipate and react quickly in case a complication arises.
- Throughout the entire patient journey, data is **collected for documentation** in the patient record, which eventually adds to continuously build and fine-tune the digital twin of the patient. These data points can be accessed during any future in- or outpatient procedures to improve the medical care (i.e. medicines prescribed, treatments suggested, etc.) the patient may receive.

Example: The interviewees highlighted that easily available data **in one interconnected interface** enables to retrieve and view the necessary patient data independently of time, location and original data source before, during and after surgery. This improves the exchange of information out of different systems.

All in all, the interviewees see digitization and the merging of all relevant patient data in one platform, which enables to create a digital twin, as a chance to enable seamless processes for an improved patient experience along the entire inpatient journey.

5 The Digital Value Generation Model's third layer: Required "Organizational Capabilities"



The prerequisite to meet the identified value generation levers is – in the experience of the interview partners – the development of organizational capabilities. If unfulfilled, not only is the digital potential left unexhausted, but rather the digital mindset and spirit fades and people loose traction in adopting digital solutions.

Overall, the survey results reveal that digitization in the O.R. is seen as an iterative process. Users find themselves in an agile, rapidly changing environment and constantly need to adapt to new technologies. It could be identified that - along with rising complexity - the digital O.R. solutions are not currently used to their full potential. The main reasons for a rather deficient use are missing system integration and licenses, missing knowledge of existing features, the assessment of the complete O.R. IT as too complicated and the availability of alternate solidly established working processes. From the users'

perspective, new digital solutions initially lead to new problems accompanied by increased time efforts, especially in the implementation and customization phase.

The main influencing factor for these prolonged processes is primarily the low interoperability of numerous different hardware and software systems in a conventional O.R. which are not "speaking to" each other. Largely, the integration of existing medical devices and software appears unfeasible at first glance and thus, hospitals continue to face a lacking holistic digital O.R. organization. Furthermore, the accelerating speed of change in the IT environment provokes a higher dependency of the hospital's IT on the supplier's 1st-level-support. As shown by these results, it is therefore all the more important to cultivate the four dimensions of organizational capacities as important success factors for the implementation of digital solutions.



Focus on IT-Infrastructure baseline and strategy – Develop a masterplan for future IT

- Develop a comprehensive and futureproof digitization strategy for connecting highly interdependent yet disparate applications, devices and technologies
- Decide for up-to-date, digital, open-platform solutions serving uniform standards to prevent malinvestments and "lock-ins" of isolated solutions
- Secure adding, modifying, or replacing technology at low costs to ensure flexibility and scalability

Manage economic funding – Be creative in pricing, funding and digital value monitoring

- Manage needed investments by flexible or result-based pricing models, e.g. with targeted modular concepts to alleviate the hospital's economic imbalances
- Improve performance monitoring of the O.R.
- Collaborate for creative funding approaches (public funding, private/ third party funding, seeking long-term co-operation with suppliers)



Supporting people in digital adoption – Create a digital mindset and invest in training and communication

- Improve the users' proficiency by increasing training intensity for hospital staff (surgeons, O.R. team as well as empowerment of technical staff) to reduce user errors and misuse
- Support tailored user training based on modular learning concepts
- Ensure transparent communication loops for new digital investments, user training and updates

Secure cyber resilience – Mobilize resources for cyber security and risk management

- Stay in contact with supplier for regular security updates to prevent security leaks in patient data
- Ensure compliance with security standards and foster risk management
- Raise the hospital staff's awareness for cyber security and the requirement for a responsible handling of digital solutions, e.g. by continuous sensitizing and reinforced training early on



6 Conclusion



Lessons learned:

The age of digitization is flooding hospitals from all sides. It is fact that the journey towards a completely digitized "Hospital 4.0" will continue. Digitized relevant information is an indispensable asset and the prerequisite for a hospital to remain viable in the future. The operating room is rated as the hospital's centerpiece and offers plenty of space for digitization measures.

It could be identified that the main focus to successfully navigate through the large-scale digital disruption lies on open-platform concepts with a high degree of data security, consistently interoperable data integration meeting uniform standards and the active digital contribution towards patient-driven care. From a hospital's perspective, demands can be divided into two levels: the basic need for workflow enhancement of supportive processes and the individual need for discipline-specific digital solutions. Hence, every hospital might have slightly different demands, highlighting the importance for targeted customization. However, to fully unfold its potentials, all inpatient stakeholders should be involved in the transformation process to comprehend the prospects of digitization and they should be digitally upskilled as early as possible.

A glance at the current financial and structural frameworks of the hospital landscape reveals huge potentials that could be addressed through digital networking structures. However, severe systemic financial imbalances are leading to tremendous economic pressure and scarce financial resources for comprehensive digitization measures in hospitals. Implementing digital networking infrastructures in the hospital's operating room might be prima facie characterized by elevated initial investments, but the value occurs over time as the organizational and individual experience curve decreases personnel deployment and the outcome of health care increases with systematically pulling all five value generation levers.

In order to pursue comprehensive and futureproof digitization measures despite the scarce resources, it might be beneficial for a hospital to consider the following aspects.

Implications for clinical practice:



Master the long run!

Why? – Digital technologies are continuously evolving, so a digital strategy should be in place that ensures flexibility and scalability during the implementation of digital O.R. solutions, suitable to individual demands but compatible with the overall system.



Prioritize digital investments!

Why? – Financial resources are scarce but investments in digitizing the hospital's core departments like the O.R. can create long-term value. The hospital's digital O.R. planning team should include the possibilities of adding, modifying or replacing technology for a futureproof concept in the project scope.



Train, explain and collaborate!

Why? – Employees are the hospital's key resource. Inducing digital competence and investing in training improves proficiency and targeted use of digital solutions. Sharing digital and medical experiences leverages medical know-how and improves quality.



Accelerate supportive processes!

Why? – The greatest efficiency potentials lie in the supportive processes such as documentation. Reduction of media disruptions and interfaces due to integrated digital systems lead to smoother workflows and free staff time for patients.



Leverage expert medical competence!

Why? – Big Data, Artificial Intelligence and intelligent medical devices activate new potentials in the areas of personalized medicine and accurate prediction. These technological developments help to specialize treatments and to stay on top of your field.



Gain with interoperability & simplicity!

Why? – People speak different languages - digital systems as well. An integrated and easy-to-use digital O.R. system can communicate with other hospitals' systems as it connects digital standards and data bases. At the same time, one central platform ensures an intuitive and easy handling for the staff.



Harmonize data flows!

Why? – The total data volume is rising steadily; high precision medicine and imaging contribute greatly to this growth. Different data flows need to be harmonized and centralized to ensure complete (even unstructured) data availability and optimal patient treatment.



Cyber security creates trust!

Why? – Just like physical buildings, digital systems are at risk of attack. Cyber security is experiencing a relevant up-swing, especially in the protection of sensitive patient data. Sensitize and protect the hospital against hacker attacks.

Endnotes

1. Stephani, V./ Busse, R./ Geissler, A.: *Benchmarking der Krankenhaus-IT: Deutschland im internationalen Vergleich*, in: Klauber, J. et al (Ed.), *Krankenhaus-Report 2019 – Das digitale Krankenhaus*, 2019.
2. Accenture: *European Hospital Rating Report*, 2014.
3. RWI – Leibniz-Institut für Wirtschaftsforschung (Ed.): *Stand und Weiterentwicklung der Investitionsförderung im Krankenhausbereich*, Endbericht – Gutachten im Auftrag des Bundesministeriums für Gesundheit, 2017.
4. Royal College of Physicians: *Underfunded. Underdoctored. Overstretched. The NHS in 2016*, 2016.
5. Healthcare Information and Management Systems Society (HIMSS) Europe: *Electronic Medical Record Adoption Model (EMRAM)*, <https://www.himssanalytics.org/europe/electronic-medical-record-adoption-model>, accessed 15 April 2020.
6. Schönermark, M. P.: *Digitale Medizin – wie verändert sich Gesundheitsversorgung?*, HNO, 2019 vol. 67 (5).
7. McKinsey: *Digitalisierung in deutschen Krankenhäusern - Eine Chance mit Milliardenpotenzial für das Gesundheitssystem*, 2018.
8. Roland Berger: *Krankenhausstudie*, 2017.
9. Densen, P.: *Challenges and opportunities facing medical education*, Transactions of the American Clinical and Climatological Association, 2011, vol. 122: 48–58.
10. Navigant: *Hospitals Could Save \$23 Billion Annually by Streamlining Supply Chain Operations, Product Use*, <https://investors.navigant.com/news-releases/news-release-details/hospitals-could-save-23-billion-annually-streamlining-supply>, accessed 11 May 2020.
11. Matheny, M. et al: *Artificial Intelligence in Health Care – the Hope, the Hype, the Promise, the Peril*, National Academy of Medicine, 2019.
12. Schönermark, M. P.: *Medical Data Management – Approach, Concepts, Strategic and Operative Implications*, Laryngo-Rhino-Otol, 2019, vol. 98 (S 01).
13. OECD: *Tackling Wasteful Spending on Health*, 2017.
14. Philipps: *Future health index 2016 report. The capacity to care: Measuring perceptions of accessibility and integration of healthcare systems, and adoption of connected healthcare.*, 2016.
15. Markets Germany: *Welcome to the Smart Hospital*, <https://www.marketsgermany.com/welcome-to-the-smart-hospital/>, accessed 15 April 2020.
16. Niederlag, W. et al: *Der digitale Operationssaal*, 2014.
17. Weerakkody, R. A. et al: *Surgical technology and operating-room safety failures: a systematic review of quantitative studies*, BMJ Quality & Safety, 2013, vol. 22: 710–718.
18. Buzink, S.N. et al: *Risk-sensitive events during laparoscopic cholecystectomy: the influence of the integrated operating room and a preoperative checklist tool*, Surg Endosc, 2010, vol. 24: 1990–1995.
19. Wallwiener, D. et al: *Integrierte OP-Systeme (IOPS) als Basis für innovative Operationsverfahren in der Gynäkologie*, Der Gynäkologe, 2011, vol. 44 (3).
20. Meppelink, A.: *Digitaler OP - bessere Planung und Kommunikation*, HNO, 2019 vol. 67 (5).
21. Himmelstein, D. et al: *A Comparison Of Hospital Administrative Costs In Eight Nations: US Costs Exceed All Others By Far*, Health Affairs, 2014, vol. 33 (9).
22. World Health Organization: *Global Strategy on Human Resources for Health: Workforce 2030*, 2015.
23. Healthcare Information and Management Systems Society (HIMSS) Europe: *Auf den Spuren der Zeitdiebe im Krankenhaus: Die wahre Belastung durch Dokumentation an deutschen Akutkrankenhäusern wird unterschätzt*, 2015.

24. Sami, A. et al: *Real-time observations of stressful events in the operating room*, Saudi J Anaesth, 2012; vol. 6: 136-9.
25. Lingard, L. et al: *Evaluation of a Preoperative Checklist and Team Briefing Among Surgeons, Nurses, and Anesthesiologists to Reduce Failures in Communication*, Arch Surg, 2008, vol 143(1).
26. Klein, M. et al: *Psychological and physical stress in surgeons operating in a standard or modern operating room*, Surg Laparosc Endosc Percutan Tech, 2010, vol. 20: 237–42.
27. Geraedts, M.: *Strukturwandel und Entwicklung der Krankenhauslandschaft aus Patientensicht*, in: Klauber, J. et al (Ed.), Krankenhaus-Report 2018 - Schwerpunkt Bedarf und Bedarfsgerechtigkeit, 2018.

Publisher

SKC Beratungsgesellschaft mbH
Pelikanplatz 21
30177 Hannover
Germany
+49 511/ 6468 14 – 0

In cooperation with

Brainlab AG
Olof-Palme-Straße 9
81829 München
Germany

