Abstract

Increased patient demands and environmental complexity make the need for transformations in the healthcare industry inevitable. Because of the rising healthcare costs due to demographic change, organizations in the industry also face a strong cost pressure. Therefore, organizations such as hospitals try to increase profitability through strategically aligned service portfolios. But how to decide upon service offerings in such a highly regulated industry as is healthcare in Western countries such as Switzerland? This case study portrays how a large university hospital in Switzerland, the Inselspital, used hospital information system data to align its infrastructure with the strategic development of the service portfolio. They visualized patient flows with interactive charts. The visualizations helped them to plan for a campus set-up with significantly reduced patient movements. With a clever strategy, they were able to convince a majority of the stakeholders to jointly take the next big step into the future of the organization.

STRATEGIC PLANNING IN HEALTHCARE

Inselspital Takes a Step Forward with Big Data and In-Memory Technology

In this case study, we illustrate how a large Swiss university hospital used in-memory data analysis on big data repositories to visualize patient flows. Did you know what major role they can play when planning the long-term strategic infrastructure?

by Alexander Schmid, Andreas Walter, and Dominique Brodbeck

The University Hospital of Bern, called "Inselspital", is one of five university hospitals in Switzerland. It offers highly specialized tertiary medical services, including transplantation services. With around 7,700 employees taking care of more than 38,000 inpatients (patients being treated stationary) and 520,000 outpatients (treated in an ambulatory), the Inselspital generated annual operating revenues of CHF 1.192bn in 2012 (Inselspital 2013). Beside patient treatment, the medical specialists of the Inselspital are involved in international research projects and the education of medical students. Today, the hospital is organized in seven directorates: Medical Directorate, Teaching and Research, Nursing/MTT (medical-technical and medical-therapeutic section), Operations, Services, Infrastructure, and Human Resources. The directorates govern a total of 40 clinics and institutes as well as more than 340 organizational units assigned to them.

Established in 1354, the institution was constituted as a charitable foundation originating from the last will of a widowed Bernese burgher woman without offspring. Its name it received in 1531, when the infirmary moved to an empty nunnery on the site of today's Federal Palace in Bern, called "St. Michaels Insel" (in English: St. Michael's Island). From 1798 onwards, the place served as a military hospital for Emperor Napoleon's French occupation troops. After being expropriated by the Canton of Bern in 1809, the hospital was reopened to the civilian population. In 1841, it was given the rights and obligations by the City of Bern to train medical students and finally, in 1884, it settled at the current location.

A "Masterplan" to Conceptualize the Future Infrastructure

Over a long period of time, the Inselspital site developed evolutionary and created path dependencies in the physical and organizational layouts. However, through innovations in medical treatment, the processual workflows developed faster than the layout of the space could be adapted. Therefore, the Inselspital, together with the Canton of Bern, set up a long-term planning project. With time horizons until up to 2060, the opportunity was grasped to correct this misalignment by optimizing the layout when enlarging the campus with new facilities or replacing old ones (Brodbeck et al. 2013). With such a

large scope, it is no exaggeration if the director of the board, Dr. Urs Birchler, calls the Masterplan Inselspital's "project of the century". Over time, all organizational units will be involved and affected by the reconfiguration of the campus.

As soon as they started the project, the most important issue for the Inselspital was the allocation of the floor space and specific functionality to the different organizational units.

To stay nationally and internationally competitive, there was a strong need for the infrastructure to be harmonized in an overall concept for future development. Therefore, the Cantonal administration initiated the "Masterplan" and presented the winner of a first architectural competition to the public in 2010. In November 2012 the project was handed over in full to the Inselspital.

The objective of the Masterplan is to expand the floor space from the current 300,000 m² to 600,000 m². However, the Masterplan is not merely a construction plan but rather a conceptualization of how the plot of the site could be arranged and set up. The heritage-protected historical buildings on the campus, erected over one hundred years ago, have to be taken into consideration as well. The floor space is distributed over the whole area, and a maximal construction volume is defined for each open parcel so that the exact architectural and constructional details of the buildings to be erected can be designed before being constructed.

The project is driven by an interdisciplinary project team, headed by Andreas Walter, and it has immediate leadership support from the supervisory board and the management board. A steering committee is governing the project politically. The committee is constituted of the director of the board, the medical director, and the director of infrastructure.

Understanding the Service Portfolio of a University Hospital

Already in an early phase, the project team realized that the spatial aspects of organizational perspectives have to be strictly separated from the building regulations. The most important issue for the Inselspital was therefore the allocation of the floor space and specific functionality to the different organizational units. Decisions upon this issue govern the procedural layout and the room arrangements. This was, however, interlinked with another highly strategic and politically relevant question: What should be the future service offerings of the Inselspital? This question had to be answered first.

The investigation into future service offerings happened at the time when the Swiss Diagnosis-Related Groups' (SDRG) case-based lump sum and procedural rate system was decided upon and introduced (see box 1). This brought a lot of uncertainty into the strategic planning process. At the beginning, the vision was to establish autonomous competence centers, grouping their service offerings according to the SDRG system. The result would have been a pyramidal model with the competence centers (the clinics) on top, subordinated by operational processes, and with the support processes at the bottom. Alternatively, the project team considered to group the service offerings according to a service cate-

Box 1: Swiss Diagnosis-Related Groups Fare System

Swiss Diagnosis-Related Groups (SDRG) is a fare system for hospital offerings based on lump sums for different treatment cases. It was introduced in Switzerland as of January 1, 2012, after a revision of the health insurance legislation. Following the system, cases in hospitals are classified into groups according to criteria such as principal diagnosis, secondary diagnosis, and treatment. Every group is assigned a fare. This fare is relevant for the health insurance claims of the hospital. Before the introduction of the SDRG, each hospital could claim a different fare for the same treatment and intervention (SwissDRG 2010, p. 2).

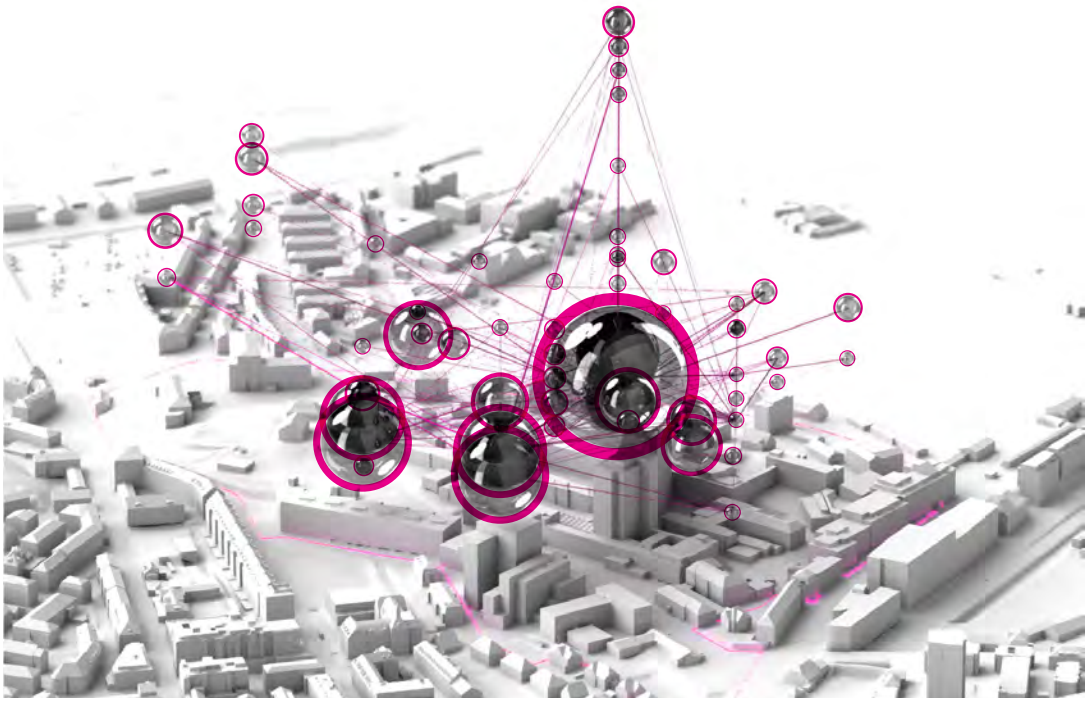

Fig. 1:
3D visualization of geographical locations where the number of patients per organizational unit is represented by the size of the associated circle (source: HENN GmbH)

gory concept, established by the Federal Conference of Cantonal Health Ministers. It turned out that the chosen approaches would not lead to a successful result. The project team was neither able to group service offerings according to SDRG nor according to the Cantonal service category concept, in a way that existing data would support a profitable service portfolio. Regardless to which reasonable dimension they turned the data cube, it did not make sense.

Accidentally, when pondering over the data, the team realized that they have the timestamp in connection to the position of each data point. With this information, the patient flow through the whole organization including the campus can be traced very precisely. The hospital can see exactly at what time a certain patient is lying in which bed (see figure 1), or in which hospital block exactly he/she is undergoing surgery or any other appointments.

Early on, the project managers realized the potential of using patient flow analysis for their infrastructure planning. They did not expect that the insights gained through this exploration would be totally contradictory to the wisdom of the organization. However, as is known from medicine, this diagnosis had to be based on evidence. It was obvious to them that visualized patient flows would reveal arguments based on evidence that would be convincing like nothing else. They focused on how the clinics could be arranged and organized to minimize the distances of patient transfers.

Patient flow analysis is not new (e.g., Côté 2000; Hall 2006; Miró et al. 2003). The focus of analysis, however, mainly lies on an operational level, optimizing throughput and minimizing waiting times. Documented cases, where patient flow analysis was used for more strategic planning aspects such as Vissers (1995) are rare. Accordingly, the team of the Inselspital could not rely on a standardized approach and had to make its own way.

Investigating Big Data via Means of In-Memory Data Management

Two professors from the University of Applied Sciences and Arts Northwestern Switzerland (FHNW), Dominique Brodbeck and Markus Degen, were brought in to support the endeavor. The data they needed for visualizing the patient flows was available. However, it was distributed over different sources, data volumes

were especially large, and it was related only weakly in terms of database logic.
Having a heterogeneous IT-infrastructure is typical for large hospitals, in particular university hospitals. One reason is that the different clinics are rather autonomous and have different needs for data types. Data of one clinic (e.g., orthopedics) is often stored in a customized IT system, and only used by that specific clinic. To cover specific needs, e.g. for research, clinics often have their own applications developed to store additional research related information. In addition, a central hospital information system is in place with electronic health records of the patients – which are also used for administrative processes in the overall hospital.
In this project, information from several sources of the Inselspital's IT-infrastructure was used and linked. One full year of data was collected from 40 clinics comprising 320 organizational units that treated 38,000 inpatients, with 180,000 transfers between the organizational units. As standard transactional databases do not typically offer the high data access performance and the versatile data types that are required by interactive multiview visualization applications, a dedicated optimized and interlinked in-memory data structure was built. This approach enabled the implementation of a fast and highly responsive user interface.
With all the data integrated and available, it had to be rendered usable for the planning experts. For the type of problems found, analysts often have only vague notions of what they are looking for: "I will know it when I see it." It was therefore crucial to make the data visible from various perspectives. For this purpose, interactive tools to identify patterns and access details in context were provided. A visual analysis application supported analysts in making sense of the collected data. The application offered four principal views:

1. Organizational (figure 2): Shows the organizational structure and how the actual medical activities shape the administrative space. A circular layout is used to arrange all the major clinics of the hospital. Circular layouts have proved effective to show genetic sequences and relationships between genomic positions. This technique was adapted to show the flow of patients in relation to the organizational structure of the hospital.
2. Systemic (figure 3): Reveals the operational structure as it emerges from patients flowing through the hospital. The movement of patients between clinics effectively creates a network of relationships, where clinics that move more patients between them are closer, or more similar, compared to clinics with fewer or no transfers. To make this network visible, a multidimensional scaling algorithm was employed.
3. Topographical: Shows the actual physical situation as a structure that evolved through many individual decisions. The topographical view shows the patient

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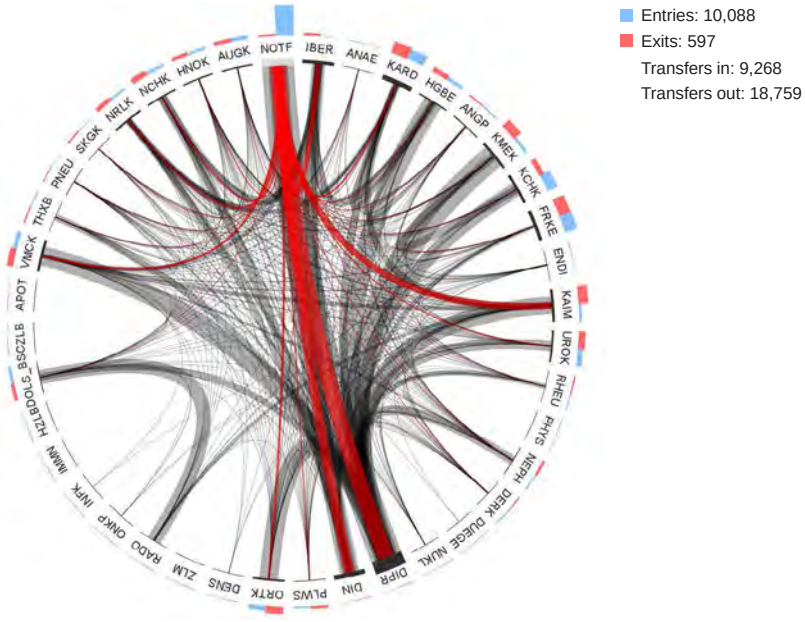


Fig. 2: Organizational map of the patient flow analysis with a focus on the emergency department (source: FHNW)

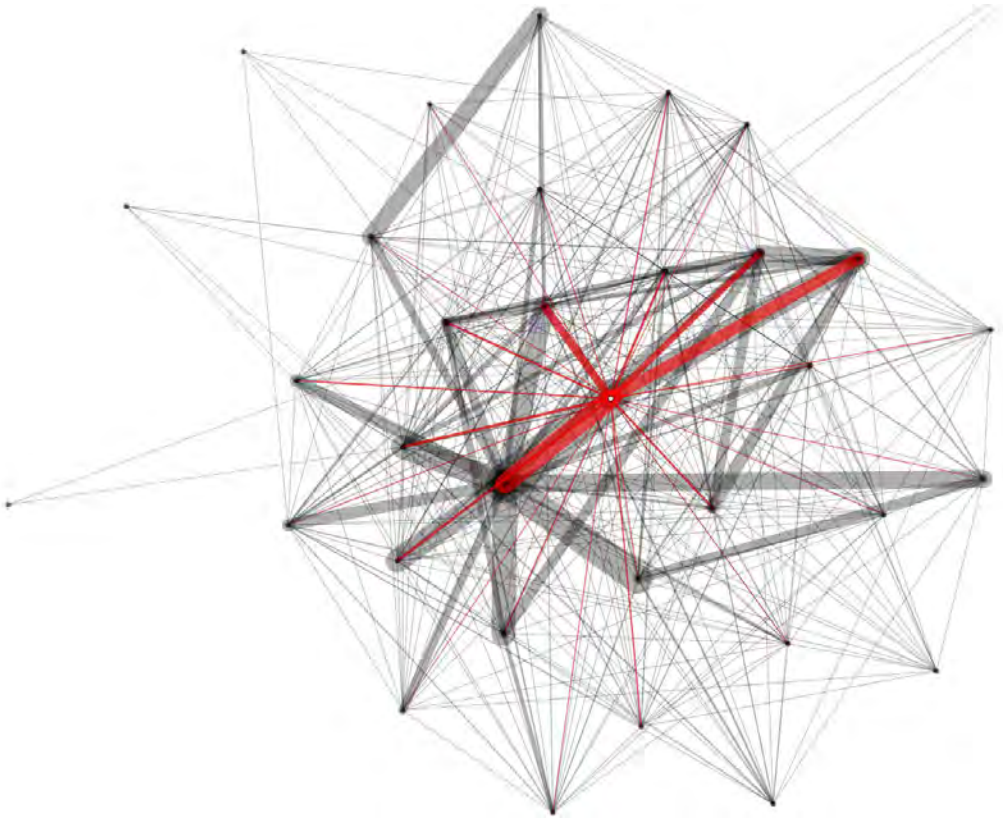


Fig. 3: Systemic map of the patient flow analysis with a focus on the emergency department (source: FHNW)

transfers on a geographical representation of the current hospital campus.

4. Chronological: Adds the dynamic view on how events and quantities change over time. The in- and out-transfers for each day are shown as a mirrored stacked bar chart. The mirroring makes it easy to spot imbalances between in- and out-flows. The net flow for each day is cumulated and over-plotted as a black line. This essentially shows the number of patients that are present in a clinic on a particular day.

In order to rationalize and interpret the insights and hypotheses generated by the four principal views, it was necessary to drill-down to the level of individual cases. Cases could be filtered either by the organizational units that they visited on their journey through the hospital, or by various categorical or numerical case attributes (e.g., destination after discharge, diagnosis, length of stay). In a separate view, all the filtered cases were shown at the same time. In order to display several hundred case histories in parallel, e.g. the variation in procedures and duration of all cases for the diagnosis “craniotomy”, their representation is condensed to a single line that is only one pixel high. Like that, it preserves the essential information about the case history.

Evidence-Based Reorganization of 2,000 Rooms

For an in-depth analysis of the existing building configuration, the visualizations were used, and the insights gained were very revealing. Based on the analysis, future scenarios could be evaluated. However, the renowned physicians and doctors practicing at the Inselspital were not exactly waiting to be told how their fields of expertise had to be reorganized. Meet-

The renowned physicians and doctors were not exactly waiting to be told how their fields of expertise had to be reorganized.

ing the experts was therefore a rather delicate issue. Accordingly, no one could foresee the pursuasive power of the chosen approach. It turned out as a surprise that the data from the information systems was unquestioned, that the visualization procedure produced easily understandable graphics, and that the results of the evaluation were correspondingly convincing.

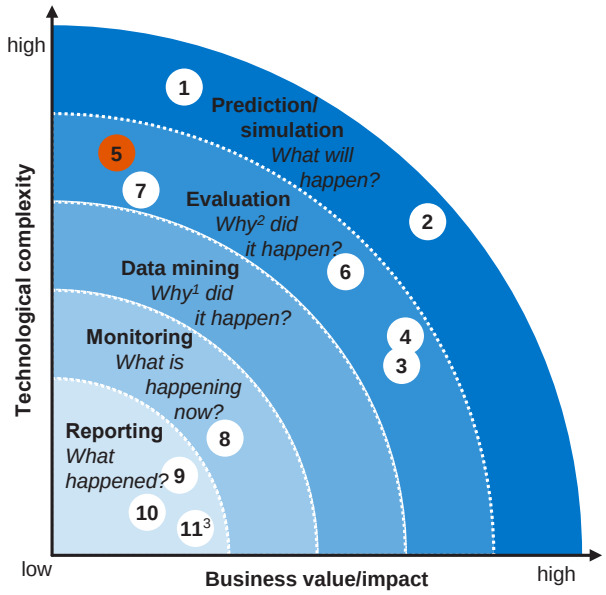
The analysis clearly showed that most of the patients received services provided by the center for intensive care, emergencies, and surgeries.

After the initial presentation of the results to the clinic managers, the plans were refined by the project team. The approach which the team chose to get the support for their plans from the business side was a dissent-consent strategy. In a draft manuscript they outlined possible service portfolio reorganizations and went from office to office to get feedback. In this process, the project team had the opportunity to explain their plans and the clinics could also raise their concerns. Consent and dissent were listed in a structured document. By revising the draft according to the feedback, the plans of the project management gained increasing support. Dissent was addressed as far as possible. The result was an agreement on the plans by clinical directors representing more than 64% of the Inselspital's total turnover.

Fig. 4: Scenario 2025 (source: Inselspital)

The analysis clearly showed that most of the patients received services provided by the center for intensive care, emergencies, and surgeries (called INO). The visualization in a systemic map shows the INO to be the "gravity center" of all clinics (see figure 4). So the Inselspital decided to upgrade the intensive care, emergency and surgery center into the functional center of the area by locating newly formed specialty clinics in the immediate vicinity. The new buildings erected on the three plots are to be brought into operation between 2020 and 2025 (HENN GmbH 2013). Until 2015, the disciplines neurology, neuroradiology, and neurosurgery will be arranged in a Neuro-center nearby the INO (see figure 4). The units which are nowadays split over the campus will be integrated. Another emphasis is placed on cardiovascular surgery being concentrated near the INO. This necessitates the complete deconstruction and rebuilding of one of the largest buildings until 2025. The planned investment into this alteration alone exceeds $480 million. In all of the respective disciplines, the Inselspital expects a growth in the number of cases by 30% in the next ten years. The third main step is the realization of a comprehensive cancer center for the diagnosis and treatment of tumor diseases until 2025. This building will likewise be allocated nearby the INO.

The reorganized campus layout should significantly reduce patient movements. Calculations resulted in an expected overall reduction by nearly 19%. Treating 38,000 inpatients a year who move 180,000 times with an average distance of 1.1 km, this equals 8,000 km saved per year. Furthermore, beside the reduced patient movements, the space allocation



1 Risk stratification/patient identification for integrated-care programs
2 Risk-adjusted benchmark/simulation of hospital productivity
3 Identification of patients with negative drug–drug interactions
4 Identification of patients with potential diseases (“patient finder")
5 Evaluation of clinical pathways
6 Evaluation of drug efficacy based on real-world data
7 Performance evaluation of integrated-care programs and contracts
8 Identification of inappropriate medication
9 Systematic reporting of misuse of drugs
10 Systematic identification of obsolete-drug usage
11 Personal health records

[1] Machine based: evaluation of data correlations only.
[2] Hypothesis based: integration of advanced analytics to determine causation, interdependencies.
[3] Higher business value expected if further enhanced and rolled out as personal health record.

Fig. 5: Big data capabilities in healthcare (source: McKinsey Big Data Value Demonstration team)

to the different clinics gains more flexibility. This allows the Inselspital to dynamically allocate functional floor space according to the varying demand of the different organizational units. With over 100 representatives of the different functions, a room and process manual with over 170 pages of explanation was developed. Based on that, an architectural competition was published to start the first building constructions. In the first plot until 2020, around 2,000 rooms will be rebuilt and organized according to the revised core, research, and support processes.

Lessons Learned

The patient flow visualization initiative of the Inselspital is one example of how the use of heterogeneous big data repositories might generate value for organizations in the healthcare industry. Compared to other use cases, the evaluation and analysis of clinical pathways and patient flows, however, have a relative high technological complexity (Groves et al. 2013, p. 18; see figure 5). As the patient flow analysis in the Inselspital was used for strategic long term planning, the business value might be relatively higher than outlined in figure 5. The complexity was revealed in this case by the effort it took to extract the data from the different information systems, the aggregation, and eventually the custom software development using in-memory technology for the evaluation.

An important lesson we can learn from the case is about the explanatory power of evidence. When exploring the big data repositories, the project team tried different approaches to model their service portfolio. Early on, the explanatory power of the visualization of the patient flows became evident. However, it took the team some effort to illustrate this meaningfully. The business side then rewarded them with a strong acceptance of the planning approach. Accordingly, finding and using the language the business speaks, means holding the key to their confidence in the strategic plans that were developed.

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In the refinement stage, the dissent-consent strategy chosen by the project team contributed an important stake in the persuasion of the involved parties. The structured collection of the dissent enabled the planning team to address the concerns without letting organizational units be opposed by newly brought up arguments. Using this strategy, the project team achieved a strong support for the plans by the different organizational units, eventually resulting in more than 64% of the total turnover pushing into the same strategic direction.

Hospitals can no longer rely on medical politics and past power allocation for long-term infrastructure planning.

The case is an example of how strategic questions can be answered and decision making can be supported by using insights from operating activities. By evaluating an appropriate measure and presenting it in an appealing form, the project team laid the foundation for the patient-centric infrastructure planning of a healthcare leader. In this iterative procedure, it was important that the involved parties aspired towards close alignment to assure their understanding for each other's perspective. The project team needed to know exactly, what the leadership team was looking for to provide answers, while the leadership team needed to understand and interpret the results of the project team's evaluation.

From a management perspective, huge potential from the technologies applied in the Inselspital case lies furthermore in the use of hospital information system data for purposes outside the strategic infrastructure planning such as e.g. disease identification, treatment effects identification, and benchmarking/simulation of hospital productivity. It is the task of strategic leaders to drive the patient-centricity of their organizations. Accordingly, hospitals can no longer rely on medical politics and past power allocation for long-term infrastructure planning. The analysis of clinical pathways and patient flows provides retrospective insights that must be considered when deciding on an organization's future infrastructure. This also requires that hospitals aspire to integrate their IT solutions and functions for a seamless move and evidence based track of the patient's way to well-being.

Key Learnings

- Speaking the language of the business means finding the evidence which the stakeholder understands. The Inselspital Masterplan Case shows, that finding the right language is key to convincing the interest groups to align on one strategic direction.
- Power allocation in the business determines the infrastructure and its development. Therefore, long-term planning for infrastructure should integrate closely with the strategic development of the business.
- With the integration of different data sources into one logical data set the explanation power of the data grows exponentially. Although this might sound trivial, it is not, especially if the data from the different data sources is loosely related and the data types do hardly match.
- The requirements of interactive multi-view visualizations which are processed with acceptable performance are often too demanding for transactional databases. More powerful tools such as in-memory processing might provide a solution.

Service

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