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## Digitisation Along the Patient Pathway in Hospitals

by

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# DIGITISATION ALONG THE PATIENT PATHWAY IN HOSPITALS

*Research paper*

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## Abstract

*The European health care system faces massive challenges due to different influences such as an aging population, multi-morbidity and an innovation-sceptical industry. Above all, hospitals are in the focus of interest, given their central importance and networking of the supply system. Due to a lower availability of resources, but at the same time increasing demands and expectations on the quality of care, hospitals are under particular pressure to optimise. Digital technologies and information systems promise valuable potential along the patient pathway with regard to increasing efficiency and improving the quality of care. This paper provides a structured literature review on the digitisation of the patient's pathway and closes the research gap to a holistic view. As part of a quantitative empirical research study, 130 German hospitals were surveyed regarding their digital potential. Therefore, a cross-sectional study was conducted to assess the current state of digital documentation and communication, as well as the identification of digitisation and integration in hospitals. The study shows interesting results regarding digital potentials, particularly concerning the internal and external communication of hospitals.*

*Keywords: Hospital, Patient Pathway, Value Optimisation, Digitisation.*

## 1 Motivation

The European health system faces numerous challenges due to multimorbidity, an aging society, massive investment backlogs, an innovation-inhibiting structure and the growing demands of digitisation (Rynning, 2008; Deiters et al., 2018). Hospitals as central health system institutions, that need to be networked with all areas, are particularly in the focus of interest (Di Vincenzo, 2018). Hospitals in Germany alone face an investment backlog of approximately 3.0 billion €, thus impairing the existing infrastructure, processes and delivered services (Deloitte, 2018). Not only do hospitals face these country-specific hurdles, but also issues that health economies are confronted with in general, such as rising costs and the shortage of skilled professionals (Schnoor et al., 2011). Further, these challenges include increased demand for medical services and resources (van Baal et al., 2018), which root in changing demographics, multimorbidity and medical- as well as technological progress (Beard and Bloom, 2015). With the limited resources given, extended demand needs to be met. This gap between actual need and potential performance results in poor execution of the underlying processes, as involved stakeholders struggle to cope with the required work load (Weissman et al., 2007). Moreover, the structural separation of inpatient and outpatient settings contributes to difficulties in the integration of stakeholders, resulting in further discontinuities in care (Adams et al., 2016).

Although maintaining the highest possible quality of care must always remain the prime focus of medical services, it is unlikely to be feasible under the challenging circumstances. The development of innovative coping strategies and lean processes is crucial to regain this objective. Digital technologies and a digital transformation of hospitals promise numerous potentials to be able to cope with the conflict between less available resources and increased demands (Deiters et al., 2018). By using information systems, smart integration of system components and the mindful consideration of users and stakeholders, the drivers of digitisation can be used to create value in hospitals (Georgantzas and Katsamakos, 2008). Particularly in the area of process harmonisation and process digitisation, the support of information systems promises a massive improvement in quality with decreasing costs (Denner et al., 2018). Inconsistencies in the medical documentation can lead to contradictory orders or findings to be recorded and archived asynchronously (Braaf et al., 2015). This does not only impair existing processes but also patient safety, as insufficient medical documentation can cause dangerous drug interactions or costly duplicate examinations. Technological assistance to these support processes allows for a leaner and more integrated design of the patient pathway, which can thereby add value and improve the quality of provided care (Garcia et al., 2017).

As part of the research project “Hospital 4.0”, funded by the German Federal Ministry of Education and Research, the patient pathway in German hospitals was examined. The project deals with the further development and implementation of innovative logistics systems in hospitals through the use of digital technologies. The aim of the research is to explore ways to leverage digital resources to improve the quality standard of patient care and the efficiency of day-to-day hospital routine. The driving forces we want to examine are the integration of different actors and processes along the entire clinical pathway, especially in the context of documentation, as reliant documentation is a crucial requirement for correct treatment and thus, a relevant influence factor for patient safety. Since a holistic view of the patient's pathway through the hospital has not yet been undertaken from this perspective, we ask the following research question.

In which way do potentials for value-optimisation through digital transformation exist in hospitals along the clinical patient pathway?

To answer the research question, the remainder of this article is organised as follows. In the following section, a systematic literature review is conducted, as this offers valuable insights on the existing research gap. Section 3 describes the chosen research method. This is followed by Section 4, which provides the extracted results. Section 5 gives an interpretation of the obtained results and draws conclusions. Finally, Section 6 presents limitations and offers possibilities for further research.

## 2 Relevant Work

Hospital care is an integral component of health systems, in which the majority of health care services are provided (Kriegel, 2012). According to the World Health Organization, hospitals provide continuous availability of services for acute and complex diseases. In order to respond efficiently to the health needs of the population, hospitals concentrate scarce resources in well-planned recommendation networks (World Health Organization, 2018). Standards, guidelines and clinical pathways have proven to be effective in streamlining diagnostics or task-related coordination processes (Smith and Hillner, 2001).

There is no standardised definition of what a clinical pathway actually is. Bleser et al. (2006) conclude the existence of various definitions in literature. They provide a basis for the definition of a clinical patient pathway. "A clinical pathway is a method for the patient-care management of a well-defined group of patients during a well-defined period of time" (Bleser et al., 2006, p. 562). Given the clinical patient pathway, medical care represents the main focus of service. The workflow of the initial assessment, diagnosis, therapy and care can be identified, which is accompanied by information, communication, coordination and decision-making. A patient pathway can be separated into two parts: core or primary processes and support or secondary processes. Primary processes focus on medical and nursing services for patients as customers. This primary process is supported by patient-related, patient-oriented and patient-remoted support processes. Support processes are activities, which are not directly aimed at the alleviation or cure of diseases, but take place in a direct manner or with the participation of the individual patient (Zapp and Aleff, 2002). As a hierarchical relationship between supporting and primary processes exists, the supporting processes are dominated by the core processes and are of subordinate importance only (Rohner, 2012). Due to the highly complex and individual medical character of hospitals' primary processes, the potential for process optimisation lies predominantly within the supporting processes, as they can be standardised to a large extent (Zapp and Aleff, 2002).

Our underlying model of the clinical patient pathway, based on Kriegel (2012), is structured into six sections, which are illustrated in Figure 1. It starts with the referral (1) to the hospital. Thereafter, the patient is admitted (2) and subsequently undergoes diagnostics (3). The next step includes the determination, whether surgery (4) is to follow and the potential performance thereof. The patient is then transferred to the ward for nursing care (5) and later discharged (6). We assign steps 3 to 5 to the primary processes and steps 1, 2 and 6 to the secondary processes. Alongside the medical support processes, others exist, with food supply and documentation of medical service provision serving as an example. However, in the visualisation of the clinical patient pathway as a fundamental of our study, the focus is on medical services.

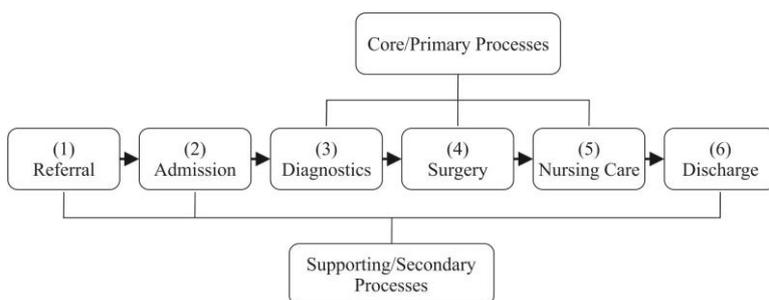


Figure 1. Clinical Patient Pathway.

Providing departments and employees with the resources required for the provision of services is an essential and success-critical value-adding factor for hospitals and therefore patient care. Value creation may be described as the sum of economic values created by activity in an enterprise during a defined period (Kriegel, 2012). The continuous quality improvement and process orientation, in combination with value creation and the transformation process, provides a significant impulse for the efficient and effective formation of structures, processes and impacts various economic areas, including the hospital sector (Sollecito and Johnson, 2012). Various companies focus on the transformation of their businesses with the use of technologies and expect higher customer interaction and collaboration (Berman, 2012).

In order to precisely examine these aspects, we conducted a systematic literature review. The aim is the profound analysis of literature and the evaluation of the status quo on digitisation in hospitals along the clinical patient pathway. To achieve a comprehensive overview of the existing literature, we conducted a systematic literature review on the formulated research question, which was primarily based on the recommendations of Webster and Watson (2002). Consequently, databases essential for healthcare settings were detected. The search was conducted in September 2018 on AIS eLibrary, EBSCOhost, PubMed and ScienceDirect. The search string „*digit\** AND (*hospital* OR *patient*) AND (*documentation* OR *medical record*)” was applied on title, abstract and key words (if available) in the database search. Within these databases, 1,141 research articles were identified. After removing duplicates, articles in other languages than English, as well as articles prior to the year 2000, the emerged pool of articles remained 689. This step was performed to ensure that the articles are not obsolete in terms of content. Furthermore, only journals with an impact factor higher than 1.0 were included, with 489 articles remaining for further consideration. This narrowing was conducted in order to receive articles of high relevance and citation performance of the journal (Zupanc, 2014). An abstract screening was performed next, resulting in 42 relevant articles. The objective was the selection of articles that match the given research question, thus involving the topics digitisation, hospital environment and documentation, or at least two of the factors mentioned. After conducting a full text screening, 17 articles were selected for further examination that included the most relevant content for our research aim – the focus, at least partially, on the clinical patient pathway. We divided the results into three categories, based on the fact that the orientation of hospitals is co-determined and shaped by a multitude of internal and external factors (Kriegel, 2012). We extend the categories of external and internal communication with the category ”opportunities by digitisation”, as this represents an essential aspect of our research objective and may, therefore, be considered separately. Addressing external communication, we refer to all factors that are included in the hospitals’ communication with external actors, such as a referral portal. In internal communication, we analyse the exchange of information within hospitals, e.g. throughout performed diagnosis or therapy. The category of opportunities comprises aspects, which indicate possibilities for digitisation in the context of the clinical patient pathway.

In the context of external communication, Boeldt et al. (2015) examine that consumers are more likely than providers to prefer using technology for self-diagnosis in non-life-threatening conditions. Their results demonstrate that consumers, as well as health care professionals, are generally supportive towards these technologies. Kimura et al. (2014) survey that patients’ attitudes are influenced by the factors “identity of recipient”, “level of anonymity” and “type of information” and that heavy criticism would arise, if the public had unlimited access to medical records, even in an unidentifiable form.

Regarding internal communication, Sakowska et al. (2017) analyse that health information systems, which fail to support the workflow, were identified as one of the top 10 patient safety concerns. Furthermore, Lu et al. (2005) and Chen et al. (2008) point out an existing knowledge gap regarding patient data security. Boeldt et al. (2015) determine that the knowledge of the perception and support of these technologies by consumers and health professionals is limited. Additionally, Chen et al. (2008) discovered significant technological gaps, such as information security expertise, that need to be closed in order to realise their potential better. In terms of personnel aspects, there is experience regarding the inability or uncertainty to use IT systems (Upton, 2008). Meier et al. (2014) detect that the management of patient-specific information is a challenging task for surgeons and physicians, as existing clinical information systems are inadequately integrated into the daily clinical routine and the information units contained are divided into different proprietary databases. Prados-Suárez et al. (2012) reveal that digitisation of the information contained in medical records and the growing availability of devices, which directly generate and incorporate digital documents, make electronic medical records unmanageable. Therefore, it will be a very difficult task to find specific information. Gillum (2013) states that the ability to capture and utilise the overwhelming amount of medical data should be a criterion for physicians, when selecting a clinical record system. Hospitals seem to be moving towards an enterprise-wide approach to IT adoption (Pedersen and Gumpper, 2008), possibly to counteract the above-mentioned complexity. According to van Poelgeest et al. (2017), significant efforts and investments on health care IT were justified because

the electronic medical record and other information systems are intended to solve the problems of variable quality and safety in modern health care. Concerning personal digital assistants, the majority of care providers find these to be convenient and practical in the areas of documentation, medical reference and access to patient data. The main barriers to the application were identified in terms of ease of use, security concerns and lack of technical and organisational assistance (Lu et al., 2005; Mickan et al., 2013). Moreover, Amin (2015) concludes that documentation is always a concern in healthcare settings and that engaging staff and providing learning opportunities is essential for the success of an IT project. van Poelgeest et al. (2017) report a shorter length of stay in hospitals with a higher level of digitisation, whereby the correlation is lower in academic-affiliated hospitals and stronger in general hospitals.

Concerning opportunities offered by digitisation, Gorman et al. (2007), Lu et al. (2005), Meier et al. (2014) and Mickan et al. (2013) detect that the usage of handheld computers results in improved information access and enhanced workflow. This regards to, e.g. more comprehensive records and fewer documentation errors and therefore, a decreased risk of unnecessary procedures. Lu et al. (2005) found that users of personal digital assistants perceived how the devices helped them to increase productivity and improve patient care. Lu et al. (2005) and VanDenKerkhof et al. (2004) see potential for clinical decision support in improved information access, which enables participants to make informed and effective decisions at the point of care. According to Kimura et al. (2014), the ability to receive treatment of the same quality at any point of care, to avoid duplicate tests or prescriptions and thus save healthcare costs, are the identified expectations of the respondents of their US-survey towards benefits of healthcare IT-innovation. Regarding the implementation of computer-based technologies in healthcare, VanDenKerkhof et al. (2004) conclude the unique opportunity to improve and expand clinical-, research-, and administrative information systems.

### **3 Digitisation and Integration of Processes along the Patient Pathway**

#### **3.1 Holistic perspective on the clinical patient pathway**

Based on the results of the systematic literature review it could be shown that all examined articles deal with isolated aspects of the clinical patient pathway only, indicating that there are no articles examining digital transformation along the defined clinical patient pathway in hospitals. The study is part of the Project “Hospital 4.0”, which is funded by the German Federal Institute for Education and Research and promises potential for improved quality and more efficient patient care through the application of digital technologies.

In comparison to the segregated literature perspectives reported, we aim to close the research gap identified within the framework of our efforts, as we introduce an overview of the entire clinical patient pathway and the integration of relevant processes and stakeholders. To ensure general validity and sustainable results, we endeavoured to create a reliable and structured study design.

Regarding the external context, consumers and providers are optimistic about new technologies (Boeldt et al., 2015), although they are strongly critical about public access to their personal data, even anonymously (Kimura et al., 2014). In the internal communication concerns about the stability of health information systems exist, including risks of collapse and potential failure in workflow support (Sakowska et al., 2017). On the contrary, there is a knowledge gap with regard to patient data security as well as to the support options of technologies (Lu et al., 2005; Chen et al., 2008). In some cases it is stated that personnel is incapable or unwilling to use IT systems (Upton, 2008). The growing amount of digital data in electronic patient records and the devices used for this documentation impair the manageability of digital medical patient records (Prados-Suárez et al., 2012). When choosing a clinical recording system, the ability of it to handle said large amount of data should be a selection criterion (Gillum, 2013). Most service providers find personal digital assistants convenient and practical in terms of documentation, medical reference and access to patient data. The main barriers to application were determined with regard to ease of use, security concerns and access to patient data (Lu et al., 2005; Mickan et al., 2013). Additionally, it was ascertained that documentation remains a concern in health settings (Amin, 2015).

Improving patient care and enabling informed and effective decisions at the point of care were identified as the most promising opportunities for digitisation (Lu et al., 2005; VanDenKerkhof et al., 2004).

Despite the increasing interest in digitisation, the influence on the improvement of processes and patient care is not yet fully investigated. Documentation along the patient pathway, as an essential part of inpatient stays, should be considered in order to avoid insufficiencies, duplicates or media breaks and thus, safety concerns and cost inefficiencies. For this reason, it is important to consider the factors jointly and to investigate influencing aspects.

### 3.2 Study design

Within this study, we contacted a randomised selection of German hospitals and submitted a questionnaire in digital and, if requested, in paper-based form. We chose physicians in leading positions as the intended target group of the questionnaire. The survey particularly focuses on the current status of digital documentation and communication. Another goal is the identification and localisation of inefficiencies in terms of media breaks and duplication, thus identifying aspects of digitisation and integration along the patient pathway.

Therefore, we used a cross-sectional study approach of a written questionnaire within the context of an ex-post facto design. Ex-post facto research is similar to experimental research, but does not modify the independent variable, as it is carried out after the data is already collected. Thus, the method retrospectively analyses plausible causal factors, verifies or falsifies hypotheses and provides cause-effect relationships between variables (Håkansson, 2013). We identified relevant variables from literature and derived unilateral hypotheses, on which the questionnaire was built. In addition to that, we derived descriptive variables to help us gain a better understanding of the given context. In order to receive specific feedback on the comprehension of the questions by participants, initial pretesting took place. Firstly, we consulted IT-specialists regarding the definition and number of answer categories per question. We did this to provide reasonable answer categories, ensuring that the questionnaire could be completed at all levels of care and specialisations. Thereafter, we asked the intended target group of this study, physicians, to evaluate the clarity and precision of the questions. These interviews involved the use of confidence ratings to assess the reliability of the given feedback. Hence, design and wording of the questionnaire rely on a two-staged iterative pretesting process. In the following standard pre-test, we reviewed the developed questionnaire under field conditions with nine test subjects and made further adjustments to wording.

The final questionnaire addresses the following four focus topics: (1) *structural classification of the institution*, (2) *external communication*, (3) *internal flow of information*, and (4) *opportunities offered by digitisation*. The questions asked concerning (1) *structural classification of the institution* include questions regarding the institutions' level of care, number of cases, length of stay and the IT-budget provided. This leads to (2) *external communication*, intending to examine existing information paths and their levels of utilisation as well as the number of media breaks and continuity of information flow between referring physicians and hospitals. Questions regarding (3) *internal information flow* ought to determine the status quo of implementation and use of hospital information systems as well as digital devices. Furthermore, questions about the status of (digital) documentation are raised. Focus topic (4) *opportunities offered by digitisation* questions, whether participants trust digitisation to leverage potential for timesaving and reduction of duplicate examinations. The following table shows the variables of the questionnaire, the response options as well as their operationalisations. The column of variables represents the subject of the respective question. Possible response options are displayed in the second column. Operationalisation depicts the applied scales and measures.

<b>Variables</b>	<b>Answer Options</b>	<b>Operationalisation</b>
Communication with practicing physicians	Telephone, Fax, Computer-Fax, Email, Hospital Platform, WhatsApp or other communication services	For every single option 1 = "Yes", 0 = "No"
Hospital linked to Referral Portal	Yes, No (if No, forward to question 2.1)	1 = "Yes", 0 = "No"
Use of the possibilities of a Referral Portal	Yes, 100%; Partially, to approx. % of the possibilities; No	1 = "Yes", 2 = "Partially", 3 = "No"
Hospital maintaining a hospital information system	Yes, No	1 = "Yes", 0 = "No"
Implementation level of the information system throughout the hospital	Percentage	Slider bar 0% - 100%
Digital input devices available in certain departments	<b>Matrix of Devices</b> (5 Enumerations – e.g. PC, Smartphone) <b>and Departments</b> (13 Enumerations – e.g. Emergency department, Wards, Radiology department, Sonography department)	1 = "True" 0 = "False"
Features implemented in hospital information system and degree of implementation	Features (28 Enumerations – e.g. Admission, Patient master data, Treatment report from emergency department, Patient Chart, Meal order, Laboratory request/findings)	Degree of implementation 1 = "Not digital" 2 = "< 50% digital" 3 = "> 50% digital" 4 = "Digital" 5 = "Scheduled to digitise"
Information that can be digitally accessed by the professionals involved in the treatment process	<b>Matrix of Information</b> (14 Enumerations – e.g. Diagnoses, Anamnesis, Medication lists, Prescriptions, Laboratory results, Allergies) <b>and Access</b> (Not possible; Scheduled; Access in less than 50% of the departments; Access in at least 50% of departments; Access in all departments; Unknown)	Access of Information 1 = "Not digital" 2 = "< 50% digital" 3 = "> 50% digital" 4 = "Digital" 5 = "Scheduled to digitise"
Current position of the hospital with regard to paper-based structures	0% = completely paper-based 50% = hybrid model 100% = fully digital	Slider bar 0% - 100%
Documentation of the displayed process steps	<b>Matrix of Process steps</b> (32 Enumeration – e.g. Admission, Anamnesis, Laboratory exams, Operating protocol, Patient monitoring, Discharge) <b>and Type of documentation</b> (4 Enumerations, see right column)	Type of documentation 1 = "Paper" 2 = "Paper → Digital" 3 = "Digital → Paper" 4 = "Digital"
Duplicate examinations avoidable by digitizing patient-related data	Yes, 100%; Partially, to approx. % of the duplicate examinations; No	1 = "Yes", 2 = "Partially", 3 = "No"
More time at the patient for doctors and nursing staff through digitisation	Yes 100%; Partially, to approx. % increase from today's level; No	1 = "Yes", 2 = "Partially", 3 = "No"

Table 1. Operationalisations.

### 3.3 Hypotheses

Regarding the intersecting issues of digital documentation and associated media breaks, we particularly focus on ownership, which we intend to link to the degree of digitised documentation. As depicted in Table 1 (*Documentation of the displayed process steps*) we derive the “degree of digitised documentation” from the amount of digital information in each process step. For this purpose, we assigned a point value to the type of documentation, in ascending order (1 to 4) from paper-based to digitised. We state:

*H 1: If a clinic is privately owned (OW), then it has a higher degree of digitised documentation (DD).*

Product and service development, as well as joint processes to coordinate supplier and customer practices constitute an interactive platform. By integrating e.g. interactive systems for order acceptance, logistics or problem diagnosis, the supplier triggers interactions with his customers. Under these circumstances, the supplier creates the opportunity to deal with the behaviour of his customers and to influence their performance (Grönroos, 2011). This customer relationship initiative can be compared to the connection to a referral portal. We consider the influence of external communication, i.e. with referring physicians, to be an essential aspect within the clinical patient pathway, assuming that communication between referring physicians and hospitals often involves telephone and fax. Hence, it is not carried out within the framework of a structured data exchange, involving all possible functions of a referral platform. This, we argue, leads to an accumulation of media breaks, which is why we conclude:

*H 2: The higher the degree of digitised documentation (DD), the greater the probability of it being connected to a referral portal (RP).*

We test the structural variable “size of institution”:

*H 3: The larger the size of a hospital (SH), the greater the probability of it being connected to a referral portal (RP).*

We further focus on the level of care. Buonanno et al. (2005) state that “business complexity” is a predictor of IT-adoption. We transfer this to the hospital context, where level of care depicts complexity.

*H 4: The higher the level of care (CL), the higher the degree of digitised documentation (DD).*

In the context explained, the structural variables “size of institution” and “length of stay” are of importance to us. One indicator of operational performance is the average length of stay. Most hospitals consider the average length of stay to be a critical performance indicator. Previous research has shown that the average length of stay is related to cost, efficiency, quality of care and speed of service delivery (McDermott and Stock, 2007). The size of a hospital is also a frequently occurring structural variable in the health sector. If a linkage between these two aspects is given, implications for the structure and organisation of hospitals are possible. Therefore, we place these variables in relation to the degree of digitised documentation and claim the following:

*H 5: The larger the size of a hospital (SH), the higher the degree of digitised documentation (DD).*

*H 6: The higher the length of stay (LS), the higher the degree of digitised documentation (DD).*

It is assumed that the current type of documentation is partly paper-based and partly digital in the companies' processes. Regarding availability, digital documentation is assumed to be superior to paper-based documentation. In addition, the number of media breaks should be taken into account, as a causality between the level of integration and occurring media breaks is assumed. A frequently mentioned example is repetitive order entry into different operational information systems within a value chain. Media breaks are comparable to missing links in an information chain and are partly responsible for slowness, lack of transparency and error susceptibility (Weintraub, 2003). We relate this to “size of institution”:

*H 7: The larger the size of a hospital (SH), the smaller the number of occurring media breaks (MB).*

As far as opportunities are concerned, we state that, through digitisation, existing weaknesses of the system can be compensated and potentials raised. The management method Lean Management has achieved great success in quality improvement and efficiency, in both the manufacturing and service sectors. Waste-related potentials are of relevance in the medical field (Kim et al., 2006), such as the avoidance of duplicate examinations and media disruptions. Therefore, we postulate:

*H 8: The higher the degree of digitised documentation (DD), the smaller the number of occurring media disruptions (MD).*

*H 9: The higher the degree of digitised documentation (DD), the higher hospitals' perceptions that digitisation can avoid duplicate examinations (DE).*

As Baidoshvili et al. (2018) describe, time saving potential through workflow optimisation based on digitisation can be realised. Thus, we conclude:

*H 10: The higher the degree of digitised documentation (DD), the higher hospitals' perceptions that digitisation can improve the patient-related time spent (PT).*

Furthermore, we focus on internal communication. According to Buonanno et al. (2005), the size of a company influences the rate of adoption of ERP-systems, which we transfer to the hospital context. Hereby, the adoption rate represents the degree of implementation of the hospital information system. Moreover, we examine the extent to which the functions of the information system are implemented:

*H 11: The larger the size of a hospital (SH), the higher the level of hospital information system implementation (HIS).*

### **3.4 Data collection and analysis**

Data collection via the described questionnaires took place in Germany from February 2017 until September 2017. Out of the total number of hospitals existing in Germany at the time of data collection ( $n = 1,942$ ), all hospitals with surgical departments were included in the study population ( $n = 1,231$ ) (Statistisches Bundesamt, 2019). This selection ensures that participating hospitals can depict the pre-defined clinical patient pathway. In order to preserve available resources, we carried out random sampling. Generating a random number for each hospital, a ranking order of the 1,231 clinics was established. We contacted the hospitals successively via telephone until we reached a level of saturation, which we set to be  $> 50\%$ . This randomised selection reduced the number to 703 hospitals (57% of the study population). 486 hospitals agreed to partake in the survey. We received 130 returns, which accounted as our final data set for analysis (response rate 18.5%). Regarding the level of care, hospitals providing primary care accounted for 21%, standard care for 37%, tertiary care for 25%, maximum care/academic affiliated hospitals for 12% and hospitals providing specialised care for 5% of the given responses. 52% of the received responses were given by hospitals in public ownership, 32% by non-profit and 17% by private providers. These percentages are approximately equivalent to the statistics on the total number of hospitals in Germany (Tiemann et al., 2012; Statistisches Bundesamt, 2019). In terms of hospital size, measured by the number of beds, the study included 26% (*national average 36%*) with fewer than 200 beds, 37% (*55%*) in the range of 200 to 499 beds and 36% (*9%*) with over 500 beds. The average length of stay over all hospitals was 6.09 days. Statistical analysis of the obtained data was carried out using analysis of variance (ANOVA) and significance testing. This test method is intended to examine whether correlations between the random sample data exist (empirical significance value  $p$ ), in which case we can assume validity for the basic population (Sachs and Hedderich, 2009). Furthermore, we analyse the number of participating hospitals using descriptive variables, allowing for a better representation of the individual characteristics.

## **4 Results**

### **4.1 Descriptive results**

The most prevalent communication channels in hospitals are telephone (94%), fax (87%), email (64%) and PC-fax (44%). Merely 20% of the participating hospitals are connected to a referral portal. Permanently installed computers currently account for the majority of digital devices in all departments, with an implementation rate of 93% to 100%. Notebooks (56%), tablets (15%) and smartphones (6%) are predominantly used on the ward, notebooks in the intensive care unit (38%) as well. Concerning hospital information systems, the study showed that 69% of German hospitals estimate their implementation rate to be over 80% (out of these, 38% show an implementation rate of 100%). Regarding the implementation

of features and the type of documentation (paper-based or digital) along the patient pathway, the following results were recorded, providing a heterogeneous picture for the first segment of the patient pathway, as only 47% of the participating hospitals show full implementation of referral in the HIS. The step of admission to the hospital is already digitally documented in over half of the clinics (56%). 93% of the participating hospitals provide patient master data from admission fully digital in the HIS. Emergency treatment reports are implemented digitally in 67% of the hospitals. The administrative registration in the emergency department is digitally documented and printed out subsequently in 22% of the clinics. Regarding diagnostics, we also take anamnesis records into consideration, which are fully or partially implemented into the HIS in 31% of the cases. Initial assessments are often (23%) documented on paper and saved in digital form afterwards. Radiology requests are fully implemented into the HIS in 85% and laboratory requests in 82% of the hospitals. 86% of the hospitals state that digital documentation is used for imaging record documents and 80% for laboratory diagnostic reports within their institution. Diagnoses are fully displayed via HIS across all departments in 81% of the participating institutions. The results showed that functional diagnostics are mapped digitally in 62% and consultation requests in 41% of the hospitals. Surgery anaesthesia documentation is represented digitally in 56% of the clinics, surgery documentation achieves the second highest implementation value in the HIS (88%). From these, 64% of the hospitals record the surgery reports directly in digital form. Electronic signatures are not depicted to a large extent (45%) and thus, can be described as mainly paper-based. With concern to nursing care, charts and medication treatment plans are represented digitally in the minority of cases (59% of the hospitals still use paper-based documentation), medication treatment plans only in 27%. In intensive care, patient monitoring is solely digitally recorded in 35% of the participating hospitals. Meal ordering is fully implemented in 78%, while bed management is mapped entirely digital in 66% of the institutions. In terms of the last step of the patient pathway, discharge, prescriptions can be issued in 47% of the hospitals through the hospital information system. In most hospitals, orders for pharmacies (74%), requests for social services (62%) and physiotherapy are already included (58%) as HIS features. In 85% of cases, the letter of discharge is displayed in the HIS, but printed after being generated.

## 4.2 Hypothesis test

Following, we present the results of the statistical analysis and depict the unilateral relations between the identified variables. A further categorisation into the given clusters of internal communication, external communication and opportunities ensues. Firstly, we carried out analysis of variance (ANOVA) to identify group differences for the variables set in relation in *H 1*, *H 2* and *H 3*, as depicted in *Table 2*. We were able to identify a difference between the groups compared in the ANOVA of *H 1*. Analysis of variance of *H 2* and *H 3* showed no significant differences between these groups.

<i>Hypothesis</i>	<i>Variables set in relation</i>	<i>Classification</i>	<i>P-Value</i>	<i>95%-Confidence Interval (mean)</i>
<i>H 1</i>	<i>OW</i> → <i>DD</i>	<i>Internal</i>	$F(2, 120) = 4.56;$ $p = .012^*$	<i>public</i> [79.20, 90.51]; <i>non-profit</i> [71.15, 87.17]; <i>private</i> [56.00, 78.54]
<i>H 2</i>	<i>DD</i> → <i>RP</i>	<i>External</i>	$F(1, 125) = .14;$ $p = .712$ ns	<i>w/ connection to referral portal</i> [72.25, 91.83]; <i>w/o connection to a referral portal</i> [75.26, 84.86]
<i>H 3</i>	<i>SH</i> → <i>RP</i>	<i>External</i>	$F(1, 32.16) = 2.03;$ $p = .164$ ns	<i>w/ connection to referral portal</i> [376.38, 710.62]; <i>w/o connection to referral portal</i> [360.65, 479.65];

ns = not significant ( $p > .05$ ), \*  $p \leq .05$ , \*\* $p \leq .01$ , \*\*\*  $p \leq .001$ .

*Table 2.* Analysis of variance.

Table 3 depicts the results of the statistical analysis of *H 4* to *H 11*. We were able to identify one highly significant (*H 5*), one significant (*H 11*) and three weakly significant correlations (*H 4*, *H 6*, *H 9*). In addition, we could further reveal three hypotheses (*H 7*, *H 8*, and *H 10*) with no correlation between the variables set in relation.

<i>Hypothesis</i>	<i>Variables set in relation</i>	<i>Classification</i>	<i>P-Value and 95%-Confidence Interval</i>	<i>Correlation Coefficient r</i>
<i>H 4</i>	<i>CL</i> → <i>DD</i>	<i>Internal</i>	.044* [-.020, .384]	.179
<i>H 5</i>	<i>SH</i> → <i>DD</i>	<i>Internal</i>	.000*** [.242, .500]	.378
<i>H 6</i>	<i>LS</i> → <i>DD</i>	<i>Internal</i>	.042* [.025, .355]	.191
<i>H 7</i>	<i>SH</i> → <i>MB</i>	<i>Internal</i>	.307 ns [-.051, .254]	.091
<i>H 8</i>	<i>DD</i> → <i>MB</i>	<i>Internal</i>	.484 ns [-.085, .218]	.063
<i>H 9</i>	<i>DD</i> → <i>DE</i>	<i>Opportunities</i>	.022* [-.361, -.014]	-.205
<i>H 10</i>	<i>DD</i> → <i>PT</i>	<i>Opportunities</i>	.799 ns [-.147, .184]	.023
<i>H 11</i>	<i>SH</i> → <i>HIS</i>	<i>Internal</i>	.005** [.102, .388]	.252

ns = not significant ( $p > .05$ ), \*  $p \leq .05$ , \*\* $p \leq .01$ , \*\*\*  $p \leq .001$ .

Table 3. Hypothesis testing.

## 5 Interpretation of Results

Digital referral platforms are currently of no relevance regarding the external communication of hospitals. The main reason for the limited integration of hospitals to referral portals is, according to Schlegel (2011), the refusal of participation by referring physicians due to the increased effort for administrative processes (e.g. manual export, import and matching of patient data). Another factor in this respect could be the lack of standardised interfaces for authorisation, signing and encryption, thus hindering smooth interaction between referring physicians and hospitals. Accordingly, external communication can be described as informal and non-standardised, which further contributes to difficulties in the provision of information and the integration of stakeholders.

Documentation is mainly paper-based, especially on the ward, although this area is most progressed in the application of mobile devices. This offers enormous potential for the reduction of inefficiencies. In the past, clinics focused on digital documentation of surgical and discharge documents, radiology and laboratory requests, as well as diagnoses and meal orders. In the near future, hospitals intend to implement patient charts, medical treatment plans and digital signatures in the hospital information system, resulting in a new holistic digital hospital infrastructure. It is a striking fact that processes requiring a signature are often documented on paper. This may be due to the reason that digital signatures, as they are standard in other industries, are not considered legally secure in the medical industry. When describing medical risks, marking of relevant passages and note-taking in the medical clarification documents are necessary evidence for potential legal disputes. The opportunity to implement digital medication lists and vital signs will be applied more frequently by hospitals in the future. However, in order to ensure an increase in efficiency, the associated role and authorisation concept must inevitably reflect the workflow in the respective hospital.

The results provided in chapter 4.2 indicate a significant difference between the ownership (*OW*) of the hospital and the degree of digitised documentation (*DD*), which are set in relation in *H 1*. The degree of digitised documentation (as measured by the BDI) differed statistically significant for the different types of ownership with  $F(2, 120) = 4.56$  ( $p = .012$ ). Tukey post-hoc analysis revealed a significant difference ( $p = .009$ ) between BDI scores of the groups with private and public ownership (-17.58, 95%- Confidence Interval [-31.45, -3.72]). Thus, we can state that private hospitals offer a lower degree of digitised documentation than public hospitals. No group differences occurred between the variables of *H 2*, the degree of digitised documentation (*DD*) and the probability of the connection to a referral portal (*RP*),

as there was no statistically significant difference in BDI scores for the measured groups,  $F(1, 125) = .137$  ( $p = .712$ ). In this respect, the character of internal documentation does not affect external connection to physicians. The causes for the connection to a referring portal must, therefore, lie in other structural aspects and require further investigation. Likewise, hypothesis *H 3* indicates no group differences between the size of the hospital (*SH*) and the probability of the connection to a referral portal (*RP*). There was no statistically significant difference in BDI scores for the measured groups according to Welch's  $F(1, 32.16) = 2.03$  ( $p = .164$ ). Assuming that the connection to a referral portal requires financial investment, we further related the size of the hospital (*SH*) to the available IT-budget and found no linkage. Thus, the connection to a referral portal represents a strategic decision, regardless of the size of the hospital. In *H 4* we were able to identify a weakly significant correlation ( $p = .044$ ,  $r = .179$ ) between the offered level of care (*CL*) and the degree of digitised documentation (*DD*). This is in virtue of the fact that higher levels of care also increase the complexity of cases. As the complexity of treated cases increases, the need to involve different actors for inter-professional and interdisciplinary coordination rises as well. Regarding *H 5*, we were able to identify a highly significant interrelation ( $p = .000$ ,  $r = .378$ ) between the size of the hospital (*SH*) and the degree of digitised documentation (*DD*). Hence, the higher the number of beds in a hospital, the higher the degree of digitised documentation. Since there is a growing administrative and medical infrastructure behind larger hospitals, more employees need to be coordinated. Therefore, we assume a growing demand for digitised documentation. In the analysis of *H 6*, a weakly significant correlation ( $p = .042$ ,  $r = .191$ ) between the length of stay (*LS*) and the degree of digitised documentation (*DD*) was identified. As the length of stay rises, so does the degree of digitised documentation. This proven statistical correlation is consistent with the statement of van Poelgeest et al. (2017), which we identified in our literature review. Complementary to this, we were able to determine a slightly positive correlation ( $p = .042$ ,  $r = .190$ ) between the length of stay (*LS*) and the level of care (*CL*). We argue, that this aspect is connected to the complexity of medical cases mentioned in *H 4*, which results in increased demand for digital documentation. In the evaluation of *H 7*, we could not establish a correlation between the size of the hospital (*SH*) and the number of occurring media breaks (*MB*). We derive this from the fact that the applied metric scale on the assessment of media breaks causes distortions, as a score is only assigned if the media form changes (paper-based or digital). With regard to *H 8*, we could not identify a significant correlation between the degree of digitised documentation (*DD*) and the number of occurring media breaks (*MB*). Accordingly, the degree of digitised documentation is not linked to the number of media breaks. In the analysis of *H 9*, a weakly significant correlation ( $p = .022$ ,  $r = -.205$ ) between the degree of digitised documentation (*DD*) and hospitals' perception that digitisation can avoid duplicate examinations (*DE*) was observed. It implies that hospitals, which already have a large number of digitised processes, increasingly distrust digitisation to avoid duplicate examinations, a result with the need for further investigation. No correlation occurred between the variables of *H 10*, degree of digitised documentation (*DD*) and hospitals' perceptions that digitisation can improve the patient-related time spent (*PT*). One possible explanation might be the subjective opinion of participants, who see process changes as additional burdens and therefore carefully outweigh the benefit thereof. The analysis of the variables of *H 11* shows a significant correlation ( $p = .005$ ,  $r = .252$ ) between the size of the hospital (*SH*) and the degree of implementation of the hospital information system (*HIS*). This confirms our initial assumption that organisational size affects the adoption rate of ERP systems, namely hospital information systems.

## 6 Conclusions, Limitations and Further Research

In this paper we investigated potentials for value optimisation through digital transformation in hospitals. Based on a survey of 130 participating hospitals, we conducted a cross-sectional study regarding the current status of digital documentation and communication along the patient pathway. This was aimed towards the identification of digitisation and integration aspects in external and internal settings. Our results demonstrate that external communication takes place in an informal and non-standardised manner. With respect to internal communication, the current status of documentation is mainly paper-based. Hospitals are being digitised for increased workflow efficiency, which, to date, is more advanced in public and non-profit institutions. The degree of digitised documentation is positively related to the

level of care, length of stay and size of the hospital. This is due to the increase in complexity, which requires the integration of a growing number of participants. As to the opportunities offered by digitisation, we were able to determine an expected increase in patient-related time.

Due to the nature of our research, this study is subject to several limitations. Firstly, given that the questionnaire contains the closed question type, the possibility of distortion concerning predefined answer categories must be mentioned. This can lead to the reduction of data quality (Baruch and Holtom, 2008). An elaborate two-step iteration process counteracted this challenge. Moreover, the decision to randomly sample the study population may be noted. This random selection does not include cluster sampling, allowing structural factors such as the ownership, size of the institution and the level of care to be taken into account. Such a division eventually would have resulted in distortions, thus limiting the applicability of statements made and was not used, as the definition of strictly differentiated clusters within the hospital market is very difficult. A distorting effect concerning the distribution of hospital sizes within the data sample, compared to the national distribution, represents another limitation. This effect may be attributed to the joint responses of several hospitals within their hospital group, thus biasing the size distribution. The statistical analysis itself remains limited by the fact that we only considered unilateral dependencies between the variables. A multidimensional description would improve the quality of statements and the illustration of dependencies. Regarding the data collection, no observation or measurement methods were performed, as these were not considered a relevant source of information due to the standardisation of the questionnaire. In addition, the measurement method used for the calculation of the degree of digitised documentation may be further developed, as a metric evaluation simplifies the given context to a large extent. Standardisation states that the same framework conditions must apply to every respondent (Faulbaum et al., 2009). Furthermore, there are limitations with regard to the sample selection. For logistical and cost reasons, only a partial survey of the existing hospitals in Germany was conducted. This limits the validity to the structural setting of the country and focuses on hospitals offering surgical care. In addition to that, as the applied model of the patient pathway according to Kriegel (2012) contains merely six process steps, possible deviating pathways were not investigated in this study. This restriction is based on the fact that only processes and associated information, directly related to the patient, are included in the study.

As the conducted study represents a first step in the holistic view of the digital patient pathway and the results depict a promising starting position, there are numerous needs for future research. Due to the heterogeneity of hospitals and forms of treatment, different patient pathways should be investigated in more detail. The identification of underlying reasons for the refusal of physicians to interact on a referral platform needs further analysis. Moreover, the structural reasons behind the rejection of *H 2* and *H 9* require investigation. This study was not designed to measure access issues, hence further research is required to gain insights on the degree of information accessibility of professionals involved in the treatment process. Additionally, future studies should engage in the investigation of factors concerning personnels' acceptance towards new technological innovations regarding process optimisations.

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