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The digital transformation applied to bed management in hospitals

A transformação digital no gerenciamento do fluxo de leitos nos hospitais

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Abstract

Purpose: This article aims to identify the benefits and difficulties managers perceive regarding implementing digital transformation (DT) in hospital bed management.

Originality/value: The article contributes to academia by analyzing a relevant topic, DT of health, that is scarcely explored in the multifactorial perspective of its technological, organizational, and social elements. No similar study was identified with application in a large private hospital located in a developing country. By analyzing managerial perceptions about implementing DT applied to hospital bed management, the study allows a better understanding and potential strengthening of this DT process by the professionals involved, which can contribute to expanding access to hospital care.

Design/methodology/approach: A single case study was carried out to investigate the implementation of DT for managing hospital beds in a private general hospital in São Paulo, Brazil. We interviewed 19 managers responsible for hospital bed management. The interviews were analyzed using two methods: content analysis and data mining, and they were classified according to their technological, organizational, and social elements (Reis et al., 2018).

Findings: DT's most cited potential benefits were efficiency gains, real-time information, and employee and patient satisfaction. The main dificulties reported were systems integration, data availability in real-time, instituting new processes, and challenges related to organizational culture and the necessary changes. DT can positively impact bed flow management, but it is crucial to consider the technological, organizational, and social elements involved in its success.

Keywords: digital transformation, health management, hospital bed, bed occupancy, hospital bed capacity

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Resumo

Objetivo: Este artigo visa identificar os benefícios e as dificuldades percebidos pelos gestores quanto à implementação da transformação digital (TD) na gestão de leitos hospitalares.

Originalidade/valor: O artigo contribui para a academia ao analisar um tema relevante, a TD na saúde, e ainda pouco explorado na perspectiva multifatorial de seus elementos tecnológicos, organizacionais e sociais. Nenhum estudo similar foi identificado com aplicação em um hospital privado, de grande porte, localizado em um país em desenvolvimento. Ao analisar percepções gerenciais sobre a implementação da TD aplicada à gestão de leitos hospitalares, o estudo possibilita melhor entendimento e potencial fortalecimento desse processo de TD por parte dos profissionais envolvidos, podendo contribuir para a ampliação do acesso à atenção hospitalar.

Design/metodologia/abordagem: Aplicou-se um estudo de caso único para investigar a implementação da TD na gestão de leitos hospitalares de um hospital geral privado de São Paulo, Brasil. Para tanto, entrevistas em profundidade foram realizadas com 19 executivos responsáveis pela gestão de leitos hospitalares. O conteúdo das entrevistas foi analisado por meio da análise de conteúdo e da mineração de dados, e classificado de acordo com seus elementos tecnológicos, organizacionais e sociais (Reis et al., 2018).

Resultados: Os benefícios potenciais da TD mais citados são: ganhos de eficiência, informações em tempo real e satisfação de funcionários e pacientes. Por sua vez, a integração de sistemas, a instituição de novos processos e a mudança organizacional constituem as principais dificuldades relatadas. A TD pode impactar positivamente o fluxo de gestão de leitos, mas é crucial considerar, para seu sucesso, os elementos tecnológicos, organizacionais e sociais envolvidos.

Palavras-chave: transformação digital, gestão de saúde, leito hospitalar, ocupação de leitos, capacidade de leitos hospitalares

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INTRODUCTION

The adequate management of hospital beds has been an old concern, which tends to increase with the population's aging (Abedian et al., 2018). The Covid-19 pandemic started in 2020 highlighted the challenge of bed management caused by the abrupt variations and the difficulty in foreseeing the demands for these resources. Hospitals face a daily challenge to meet the needs of patients being admitted into hospitals, and the costs of not providing patient care, whether due to the lack of beds or their inadequate management, cause high impacts for private organizations and governments when generating queues in hospital emergencies and canceling surgeries (Abedian et al., 2018; Raffa et al., 2017). This theme is a priority in managing public and private health institutions in order to increase access and meet the population's health demands.

The management of beds is complex due to its interaction with several areas in the hospital, and it can generate bottlenecks and inefficiencies in the flow of patients (Kerpedzhiev et al., 2019). These inefficiencies cause waiting queues in the emergency department, the postponement and cancellation of surgeries, or the allocation of patients to beds that are not in line with their needs, negatively affecting the work of the care team and leaders, as well as the patient treatment (Baru et al., 2015). Addressing these issues can be solved by expanding operational capacity and investing financial resources to increase the number of beds, facilities, and human resources. This option is not the most appropriate given health organizations' economic and competitive scenario (Waring & Alexander, 2015). It is therefore necessary to seek more efficient management of existing resources and information technology (IT) to help control and coordinate beds (Raffa et al., 2017). New technologies linked to digital transformation (DT), such as big data, artificial intelligence, cloud computing, blockchain, the internet of things, social networks, and the internet, offer new management resources based on innovation and consumer needs (Haggerty, 2017). However, implementing these technologies is not enough to make the organizations digital and improve management. DT presupposes changes in business models and strategy, structural processes, and organizational culture (Nadkarni & Prügl, 2020; Hanelt et al., 2021; Reis et al., 2018). Implementing IT in hospitals is an arduous process requiring investments for deployment and maintenance (Sullivan & Staib, 2018; Raffa et al., 2017). As a result, hospitals historically have not presented satisfactory results in implementing information systems (Raffa et al., 2017; Waring & Alexander, 2015).

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Given the importance of adequate bed management for the health sector and the possibility of using new digital technologies for bed management, the intent here is to identify the benefits and difficulties experienced by managers regarding implementing DT for managing hospital beds.

In order to achieve this objective, we opted for a single-case study developed in a large private philanthropic hospital in São Paulo that evaluates and deploys digital tools to assist with bed management. The institution's managers are already facing the DT implementation difficulties reported in this study, and the reported benefits are a mixture of the benefits already identified and expectations of future benefits not yet materialized. The material collected in the field was analyzed considering the three elements that define DT (Reis et al., 2018): technological, organizational, and social.

This study is relevant for society because implementing DT in bed management can increase hospital capacity and population access to hospital admissions (Alam et al., 2020; Mahraz et al., 2019). Increasing access is especially important in developing countries (Alam et al., 2020), as in Brazil, where the average number of beds for every 1,000 inhabitants is 2.3. In contrast, the World Health Organization (WHO) recommends three beds per 1,000 inhabitants (Finkelstein & Borges, 2020). This study is relevant for academics in gathering the perception of several managers who participate in bed flow management on perceived benefits and perceived difficulties regarding implementing DT in the bed management process since this subject is still little researched, especially in developing countries (Alam et al., 2020). For managers, this study is relevant for providing information about the potential challenges faced in their organizations' DT processes.

After this introduction, the next section presents a literature review covering bed flow management and its challenges, DT in hospital bed management, and DT's potential benefits and difficulties. Next is the research method, the presentation of the hospital analysis, the results and analyses, and finally, the conclusion of the study, pointing out the contributions of the research, its limitations, and suggestions for future research.

LITERATURE REVIEW

Bed flow management, its challenges, and digital transformation

Patients, society, and other stakeholders have demanded improvement in both private and public health care, and bed management has become an

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important criterion in providing quality health services, leading most hospitals to have a bed management team for capacity planning (Kerpedzhiev et al., 2019; Baru et al., 2015).

In health, the term flow represents the movement of patients, information, or equipment between departments as part of the patient care route. Patient flow management is complex and involves bed management to allow patients to have access to beds that are appropriate to their needs and to reduce the number of patients who are turned away due to the lack of an available bed (Kerpedzhiev et al., 2019; Baru et al., 2015).

The pressure for beds arises as a challenge to be overcome that calls for new business models such as daytime surgery, improved recoveries, specializations, and telemedicine (Allen, 2015). In addition, there is still a need for tools that make it possible to track the patient's journey between hospital areas. Having the necessary number of beds to meet demand is a recurring problem in bed management, and therefore, hospital capacity planning is a widely researched subject in health management (Kerpedzhiev et al., 2019; Baru et al., 2015).

Although the decision to discharge a patient should be predominantly clinical, there may be non-clinical factors that extend bed use even if the patient is released by the hospital, such as the unavailability of the family members to pick up the patient or the patient may need to wait for an exam report, for example. So, since admitting patients and the various sectors of the hospital had an approximate idea of when they would be discharged, the patients and their family members could schedule themselves in advance. The bed managers and the receiving ward personnel could use this information to assist in planning patient movement, bed allocation, personnel allocation, and feeding. This measure would certainly improve resource allocation and reduce the waiting time for a bed (Cameron et al., 2015).

Regarding managing the beds in the intensive care unit (ICU), which is the area with the most complex and costly resources for hospitals, the discussion of the ideal number of beds for both a given population and a particular hospital is essential (Barado et al., 2012). Another challenge is managing emergency beds, considering that the overcrowding of these services generates long waits in addition to patient dissatisfaction and possibly going elsewhere (Cameron et al., 2015). This agglomeration involves a complex dynamic of several interconnected processes, so analyzing just one department is not an option (Raffa et al., 2017).

Monitoring the efficiency of bed management is essential. The main indicators used are as follows:

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- *Mean length of hospital stay*: the relation between the total number of patients/day and the total number of patients who left the hospital in a given period, including deaths.
- *Hospital occupancy rate*: the percentage ratio between the number of patients/day and the number of beds/day in a given period.
- *Replacement interval index*: the average time that a bed remains unoccupied between one patient leaving and another patient being admitted (Raffa et al., 2017; Rocha et al., 2018).

Previous studies have shown that the more productive hospitals have a lower mean length of stay, higher turnover rate, and a lower replacement interval index (Raffa et al., 2017).

Several studies have sought to define DT and investigate its implementation to assist in bed management. Reis et al. (2018) reviewed 206 articles on the theme and based on the analysis of several definitions came to the conclusion that DT can be defined based on three distinct elements:

- *Technological*: DT is based on using new digital technologies such as social media and mobile devices.
- *Organizational*: DT requires a change in organizational processes or creating new business models.
- *Social*: DT is a phenomenon that influences various aspects of human life such as the customer experience.

The authors define DT as the use of *new digital technologies*, which allow for *business improvement* and influence all *aspects of consumer life*, impacting processes, resources, values, and organizational culture (Hanelt et al., 2021; Sullivan & Staib, 2018).

As for the deployment of DT for bed management, simulation models have been developed and implemented to improve bed allocation and minimize bed idleness (Barado et al., 2012; Landa et al., 2018). Dai and Shi (2019) described the development of an algorithm system to assist hospital managers in Singapore. Waring and Alexander (2015) investigated the implementation of a bed management system in the United Kingdom through the innovation diffusion theory, according to which an innovation can be seen as something new to an adopting organization without necessarily being new. Iran's Ministry of Health and Medical Education implemented an online system that shows the status of beds in real-time with a national alert system. The system allows for tracking patients, managing patient allocation in health centers, and providing extra beds (Abedian et al.,

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2014; Abedian et al., 2018). The study by Rocha et al. (2018), developed in Brazil, analyzes a graphic app available on computers and mobile phones that uses color logic (*Kanban*) to signal the flow of patients. The research by Grübler et al. (2018), also developed in Brazil, analyzed the use of a hybrid model that uses an artificial neural network and the multiple-attribute value theory (MAVT) to manage the emergency wait list and scheduled patients.

These studies indicate several benefits of implementing DT in bed management but also point out the difficulties faced in the process. These benefits and challenges are presented in the next two sections and structured according to the three DT elements proposed by Reis et al. (2018).

Potential benefits from DT in bed management

Technological element

Some authors point out that DT improves the *flow of information*, making it available in *real time* (Williams et al., 2019; Abedian et al., 2014, 2018; Raffa et al., 2017). The accuracy of the information and the vision of the patient's journey make it possible for hospital institutions to optimize the use of physical and human resources. Furthermore, real-time information helps the planning and execution of actions according to the reality and specificity of the service (Raffa et al., 2017). Sullivan and Staib (2018) point out that DT allows for greater *transparency* and *visibility* of processes, while Raffa et al. (2017) mention the greater *integration of information*.

Organizational element

The increase in process *efficiency* appears in the literature as a great benefit of DT. DT allows simultaneous assessment and monitoring of the bed occupancy profile and adequately calculates bed capacity and how many are needed (Mahraz et al., 2019; Raffa et al., 2017). Implementing DT is associated with increased bed turnover, reduced waiting time, and consequently increasing the population's access to hospital care (Alam et al., 2020; Mahraz et al., 2019; Raffa et al., 2017). DT can also simplify and integrate processes within the organization, making it more agile and adaptable to changes in demand, which increases organizational competitiveness (Mahraz et al., 2019). Another benefit related to the increase in efficiency is the possibility of *predicting* the probability of admission to emergency care (EC), helping to predict admissions (Barado et al., 2012; Cameron et al., 2015). Williams et al.

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(2019) add that DT can potentially increase decision-making speed and reduce information asymmetry within the organization.

Social element

Some authors mention the benefits of DT *for patients* in bed management (Landa et al., 2018). More efficient processes increase *patient safety* and the *quality of care services* while reducing costs and improving patient experience (Alam et al., 2020; Mahraz et al., 2019; Williams et al., 2019).

There are also benefits related to the *employees*. Haggerty (2017) points out that DT allows employees more access to historical and real-time patient data, helping to provide safer services. For Raffa et al. (2017), DT can help employees perform tasks more efficiently, increasing organizational efficiency.

Difficulties of digital transformation

Technological element

As for the *technological* element of DT, the adequacy of information systems for greater applicability to hospitals is still challenging, and technical issues are among the main reasons for the failure to implement DT (Raffa et al., 2017). In addition, DT requires an adequate infrastructure, has a high deployment cost, and requires ongoing technical support and technological maintenance. There is also concern about the obsolescence of the technology acquired (Sullivan & Staib, 2018; Raffa et al., 2017; Hermes et al., 2020).

Another difficulty is the integration of the various hospital systems that are mostly disjointed and difficult to combine (Sullivan & Staib, 2018; Raffa et al., 2017; Haggerty, 2017) with challenges also regarding the security and privacy of information, which are generally protected by law (Haggerty, 2017; Hermes et al., 2020). Additionally, the system often does not meet the needs and expectations of the users (Sullivan & Staib, 2018; Raffa et al., 2017; Hermes et al., 2020).

Organizational element

There are several difficulties from the *organizational* perspective, and one of them refers to the awareness and willingness of hospital managers to make the changes and interventions necessary for the proper implementation of digital technologies. Adjusting the *processes* to the changes needed to

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implement the DT is difficult because integrating digital with traditional business models is challenging (Reis et al., 2018). DT depends on properly managing the changes, including new business models, processes, structure, and organizational culture (Allen, 2015; Raffa et al., 2017). In addition, people need to be trained for the new process and to develop new communication skills in the work environment (Nadkarni & Prügl, 2020; Reis et al., 2018; Mahraz et al., 2019).

Some authors report the loss of productivity during the transition of the processes to digital and that rapid transitions can reduce the quality of the services and put the safety of patients at risk (Alam et al., 2020; Hermes et al., 2020; Sullivan & Staib, 2018). There are also challenges related to the quality of information. Input errors, duplications, and omissions of retrospective data occur very often (Raffa et al., 2017; Abedian et al., 2014; Cameron et al., 2015; Waring & Alexander, 2015).

Another challenge is that DT dissolves the traditional hierarchical structure and routines (Nadkarni & Prügl, 2020). With DT, it is possible to make a more shared decision among physicians and nurses, allowing nurses to participate in strategic decisions related to the allocation of patients (Allen, 2015). For this benefit to become a reality, a culture of data and information sharing is needed, which does not always occur in the health sector (Nadkarni & Prügl, 2020). Finally, the increased visibility and transparency of the processes may reveal problems and omissions that were not visible before the DT (Sullivan & Staib, 2018).

Social element

Studies reveal a great impact of DT on people – patients, doctors, and employees. The employees may negatively impact patient experience during the adaptation period to the new technologies (Alam et al., 2020; Hermes et al., 2020; Sullivan & Staib, 2018). There is also the possibility of resistance from doctors who may fear the loss of autonomy, or if the system is not friendly, feel like they are wasting time with data input because they are not taking care of patients (Hermes et al., 2020).

Employees can also resist the changes and often do not adhere to the new technologies (Alam et al., 2020; Sullivan & Staib, 2018; Raffa et al., 2017). With digitalization, all events and data are recorded and can be easily retrieved and seen in the organization, which can cause fear, anxiety, and resistance to new technologies (Sullivan & Staib, 2018). According to Sullivan and Staib (2018), fatigue and depression can occur at the individual or institutional

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level after the necessary changes are made for implementing the DT. Another possible problem during the implementation of the DT is the increase in the gap between the professionals regarding the ability to navigate in the digital world, generating conflicts among the institution's employees (Nadkarni & Prügl, 2020).

RESEARCH METHOD

Study design and choice of the case

The choice of the case study as a research method was based on its suitability to the research objective, which is to investigate the implementation of DT in bed management in a large hospital located in the most populous city in Brazil. Case studies help explore answers to the questions "how?" and "why?" as well as to describe "who", "what", and "where" (Yin, 2001). The present exploratory study sought to answer questions along those lines, such as: how does the process of managing beds in the hospital take place? What difficulties and benefits are perceived in the DT implementation process for controlling hospital beds? DT is a complex process and intrinsically linked to the organizational, technological, and social context of implementation since using new digital technologies in bed management impacts processes, physical and human resources, organizational values, and culture. The relevance of contextualization and interrelation of factors for the investigation, the complexity of the study object, and its intricate relationship with the context make the case study a relevant strategy (Creswell, 2014; Creswell, 2010).

The choice is also linked to the ontological and epistemological positioning of the research, which is quali-quantitative (due to the understanding that the research problem can be better understood and the results can be better interpreted by combining more than one method of data analysis) and an interpretative paradigm (assuming that reality is not external to the actors involved, but built by the subjects who attribute meanings when interacting with the research objects) (Creswell, 2014; Creswell, 2010; Orlikowski & Baroudi, 1991).

Specifically, the single-case study was chosen because it is a new subject with little structured knowledge (Yin, 2001; Flyvbjerg, 2006). The single-case study is advantageous when there is a logical basis and the case is decisive. Furthermore, although a single-case study deals with a single organi-

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zation, the analysis may include results from several departments or units (Yin, 2001). This research was carried out in a single hospital. Still, it covered the different perspectives of the various sectors and managers involved in the process: some responsible for managing the beds, others responsible for requesting beds, and sectors engaged in the bed turnaround process, such as maintenance and housekeeping.

This choice was made because, at the time of the research, the hospital analyzed was undergoing an evaluation of digital tools to assist in managing the beds due to the coverage and complexity of the institution's bed management process. There are five business units besides the sectors of bed control, hospitalists, building maintenance, and housekeeping. The ease of access of researchers to the institution was also considered since one of the authors works in the institution investigated, enabling access to several managers and to the hospital's documents and information. Data collection and the profile of respondents are detailed in the next section.

Data collection

Nineteen institution managers who directly or indirectly impact the hospital bed flow were interviewed between August and October 2020. The interviews were recorded, later transcribed to facilitate the analysis, and validated by the interviewees. This was done to bring different points of view on the theme to the research. In order to increase the research's internal validity, a triangulation of the information collected was performed by analyzing the institution's documents and reports and by direct observation of the researcher during visits to the various hospital sectors during the research (Yin, 2001). The documents analyzed were as follows: Patient Care (profile of units), Patient Admission, Emergency Care Admission, Criteria for Admission and Discharge from Critical Units, Scheduling of Surgery and Patient Referral to the Surgical Center, Patient Admission – Control and Distribution of Beds, Patient Admission – Discharge of Hospitalized Patient. As for the observation, a visit was made to the sectors involved in the bed management process. One of the authors spent about ten hours observing and analyzing the bed management process in each sector. The information collected made it possible to identify convergences and discrepancies.

Table 1 presents the profile of those interviewed, who will be identified as E1, E2 etc., to preserve their identities.

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Table 1

Profile of interviewees

Nature	Sector	Interviewee	Education	Position
Presidency	Presidency	E19	Doctor	Assessor to the President
Bed control	Critical Cardiology Units	E11	Biomedicine	Administrative Manager
	Critical Cardiology Units	E12	Nurse	Care Manager
	General Critical Units	E9	Doctor	Medical Manager
	General Critical Units	E10	Nurse	Care Manager
	Bed Control	E13	Nurse	Coordinator
Bed requesters	Patients Admitted	E1	Doctor	Medical Superintendent
	Patients Admitted	E2	Administrator	Administrative Manager
	Emergency Care	E5	Nurse	Care Manager
	Surgical Unit	E8	Nurse	Care Manager
	Emergency Care	E4	Doctor	Medical Manager
	Patients Admitted	E3	Nurse	Care Manager
	Surgical Center and Emergency Care	E6	Administrator	Administrative Manager
	Surgical Unit	E7	Doctor	Medical Manager
Bed turnover support	Maintenance	E17	Engineer	Administrative Manager
	Housekeeping	E16	Administrator	Care Manager
	Facilities Director	E15	Nurse	Superintendent
	Medical Practices	E14	Doctor	Medical Manager
	Patients Admitted	E18	Administrator	Administrative Coordinator

The interview script was based on the literature review, which sought to identify DT's social, technological, and organizational elements, as Reis et al. (2018) proposed. At the beginning of the interview, the interviewer briefly explained what was meant by DT in order to align the understanding of the term. The interviews were face to face or conducted using the Zoom Meeting platform and lasted an average of 40 minutes. The interview script is presented in the Appendix to increase the reliability of the study.

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Analysis of the information collected

As previously mentioned, the analysis of the material collected in the field considered the three elements proposed by Reis et al. (2018). These three dimensions must be analyzed together and are essential in building a digital strategy and in identifying the gaps to be filled when starting on the journey called DT (Tratkowska, 2020).

In order to increase the validity of the construct, two methods were adopted for analyzing the interviews: content analysis and data mining. Content analysis leads to systematic and qualitative descriptions that help interpret messages and better understand their meanings (Bardin, 2011). We opted for targeted content analysis in which classification codes are defined *a priori* (Bardin, 2011; Hsieh & Sharnnon, 2005) based on the elements proposed by Reis et al. (2018). Verifying and discussing the categorization by the authors made it possible to remedy the divergences together. The phenomenon was interpreted and understood to contrast the findings with the pre-existing knowledge. In the analysis, the intent was to meet the criteria of validity, completeness, and homogeneity, as prescribed by Moraes (1999).

In turn, mining the interview texts using techniques of extraction and analysis of words generates numerical indexes for quantitative exploration of the interviewees' answers (Feldman & Sanger, 2007). The TF-IDF (*Term Frequency – Inverse Document Frequency*) value, which is a statistical measure indicating the importance of a word in a document, increases proportionally as the number of occurrences in a document increases. However, this value is balanced by the frequency of the word in the set of documents. Thus, the more a word appears in different interviews, the greater its TF-IDF value (Feldman & Sanger, 2007). R software (version 4.0.3) was used for the mining process.

The next session presents the main characteristics of the hospital analyzed.

THE HOSPITAL

This is a general quaternary, philanthropic hospital located in São Paulo. In 2020, the hospital had 529 operational beds, 139 ICU beds, 43 semi-intensive beds, 66 semi-critical units, 258 non-critical beds, and 23 pediatric beds (6 ICU and 17 non-critical beds). The Hospital has an average hospital outward flow (discharge, evasion, withdrawal from treatment, internal

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transfer, external transfer, or death) of 2,032 patients a month. The hospital is a reference in oncology treatment and general surgeries. In 2020, the clinical hospital outward flows were 48%, and surgical ones were 52%.

The hospital uses operation management indicators to monitor bed flow, such as occupancy rate, mean length of stay, replacement interval, and bed turnover. Between January 2015 and December 2020, the mean hospital occupancy rate was 80%, the mean stay was 5.34 days, the mean bed turnover rate was 4.45 times a month, and the mean replacement interval index was 1.7 days. The institution's bed management process is detailed in the next section.

Bed management

Bed management is semi-centralized: there is a bed management area that manages non-critical beds, semi-critical beds, EC requests, and external transfers, while the managers of the Critical General and Cardiology Business Units control the openings of the critical beds. E13, the Bed Management Department Coordinator, commented: "If these were to go through us, we would be able to have a view of the entire hospital [...]. Indeed, it would be easier for us if that came under our domain".

Requests for beds can come from three distinct groups: from doctor offices, from emergency care, and from external transfers. When there is a bed request, the availability of beds and possible discharges must be evaluated. Once the bed has been "reserved", it should be open for use after two approvals: medical discharge (with the doctor's signature on the electronic medical record) and administrative discharge.

It is not uncommon for bed control to see on the system that a certain number of beds are unavailable when the patient has left the hospital, but the system has not yet been updated. The patient leaving is critical to starting the bed cleaning process. As mentioned by E1: "A policy has been established that the patient should leave the hospital room by 11 in the morning, but there is a lot of flexibility in relation to the patient's departure time".

Housekeeping is responsible for cleaning the bed, which starts when this is indicated in the system of the patient leaving the room. In the course of cleaning, if the team identifies the need for repair, they will contact Maintenance by telephone. Maintenance then sends a service order via WhatsApp to the "Command Center". The room is only cleared for the subsequent use after repair. The Maintenance System is not integrated into the Housekeeping System. As pointed out by interviewee E17:

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> I think that this lack of having a single connection tool with the areas, or this need, will help us a lot..., each person taking care of their own, but being able to work based on the big picture, which is the operational bed.

The bed request process is considered time-consuming, with too many steps. Although there is an electronic medical record for doctors, the bed request is done manually by filling out a form transcribed by the administrative assistant. The process is not transparent and requires many calls to get information regarding approving the bed for use.

The hospital has Hospitalists who are physicians who care for the non-critical hospitalization units. Some managers believe that the hospitalist's role in the discharge process should be sporadic because this team's strong participation in the process reflects that it is inadequate. The technologies applied to manage the institution's beds are described in the next section.

Technologies applied to hospital bed management

The hospital uses the following technologies to manage its beds: Enterprise Resource Planning (ERP), telephone, WhatsApp, a specific Hygiene System (HS) software, a particular Maintenance System (MS), a hospitalization unit panel made available on television at the nursing stations in the hospitalization units with the primary patient information, and a notebook for keeping a manual control by the care leader over the critical units.

Nine of the interviewees (47%) believe that DT has been applied to assist in bed management, five (27%) think that not, four (21%) believe that partially, and one interviewee (5%) says that they do not know the current systems used in bed management. It is interesting to observe the variation in perception among the managers who work with the flow of beds in the institution, demonstrating the diversity of interpretations of the term DT. It was also asked if the hospital has real-time data: seven interviewees (37%) answered *yes*, seven (37%) answered *no,* and five interviewees (26%) said that they did not know. It is interesting to observe the discrepancy in the perceptions of the managers interviewed.

Regarding the perception of the adequacy of these tools, nine interviewees (47%) answered that they considered the tools to be appropriate, five (26%) responded that they did *not* think so, and four (21%) answered that *partially*. Some managers answered *yes*, even with the manual process, due to the control over openings in the critical units. Those who believe that

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the tools are *not* adequate mentioned the delay in updating information on the status of beds due to manual inputs not following the changes in patient and sector needs in real-time. Those who answered *partially* mentioned WhatsApp, which is considered agile and collaborative but does not have the feature to search for information. Some areas work on an analog basis, which does not allow the integration of hospital data.

It was mentioned that having the correct tool to ensure quality bed management is insufficient if processes are not performed according to the existing policies. This understanding aligns with several authors' perceptions (Nadkarni & Prügl, 2020; Reis et al., 2018, among others). The interviewees presented 25 points for improving the existing processes. In the *organizational* dimension, the need to improve the processes was reported, especially regarding not following the policies regarding hospital discharge time. As for the *social* dimension, the need was mentioned to raise employee awareness about the importance of properly feeding the system. Regarding the *technology,* the interviewees highlighted the need for standardized information through system integration.

OUTCOMES AND ANALYSES

Benefits perceived by the managers

As can be seen in Figure 1, for the interviewees, the most significant benefit of DT would be to increase the efficiency of the processes (mentioned 45 times during the interviews), followed by increased patient satisfaction (mentioned ten times), improved information quality (seven times), greater process transparency (five times), greater care safety (two times), higher employee satisfaction (two times), and the possibility of integrating all systems (once). When the benefits are grouped into the three elements of analysis adopted in this study, the organization's benefits are highlighted, followed by the *social* benefits, and, finally, by the benefits related to the *technological* dimension.

When the benefits are grouped into the three elements of analysis adopted in this study, the benefits of organization are highlighted, followed by the social benefits, and finally by the benefits related to the technology element (Figure 2).

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Figure 1

Key benefits expected by respondents based on the frequency of citations during the interviews

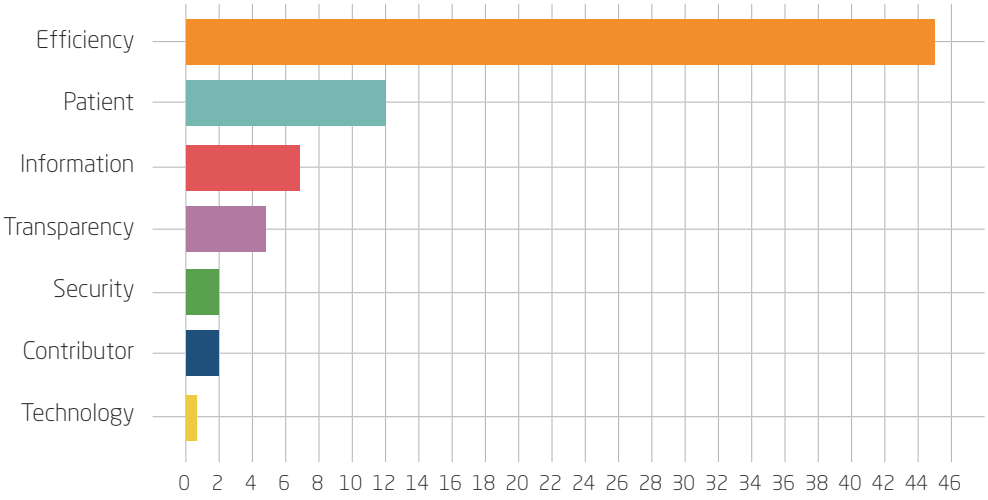
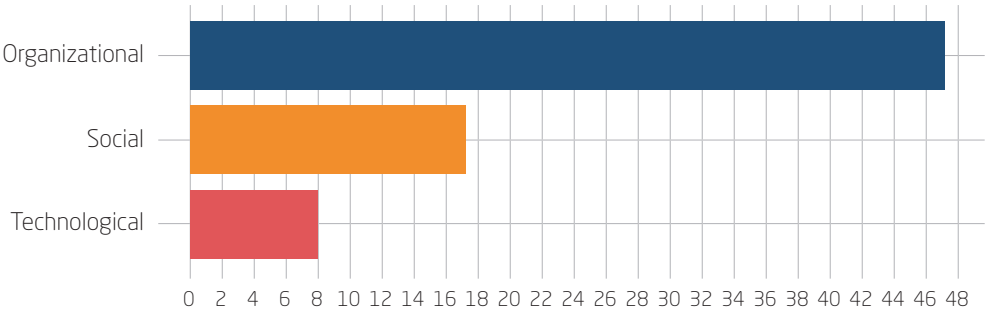


Figure 2

Frequency of answers related to benefits, grouped by DT elements



Benefits related to the organizational element of DT

For the interviewees, the increase in bed management efficiency is the main benefit of DT, corroborating with the previous literature on the theme (Landa et al., 2018; Rocha et al., 2018, among others). According to the interviewees, DT in the bed management processes will enable greater trans-

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parency and process optimization at reduced costs and better prioritization of patient allocation. This understanding aligns with Raffa et al.'s findings (2017) in a previous study conducted in Brazil. Based on the *predictive information*, a better allocation of human resources, equipment, and inputs would be possible, as the literature proposes.

Those interviewed believed that through *real-time information*, quicker and more assertive decision-making would be possible with a reduction in rework. The entire bed management chain will also have greater transparency, providing the fastest patient freeing up the bed. In the words of E2: "By turning over the bed and providing a more efficient management in this sense, we have a virtual gain in capacity since with the same number of beds and human resources, we can optimize these resources". The revised literature also identified these benefits (Williams et al., 2019; Sullivan & Staib, 2018, among others).

Another benefit related to the organizational element is the increase in *care safety*. For the interviewees, the patient needs specific care based on the pathology presented and needs to be allocated to the appropriate bed. Another question raised regarding patient safety is the waiting time for the bed, especially with patients coming for an emergency. Those interviewed believed these points would be improved by streamlining the bed management process. This understanding is in accordance with the revised literature (Alam et al., 2020; Mahraz et al., 2019).

According to the TF-IDF statistical analysis, the most important words regarding the organizational element are as follows: decision-making, quick decision, will need it, hospitalization units, set targets, and the entire process. These terms complement the content analysis, reinforcing the perceived benefits of increased efficiency through faster decisions and other elements that will have more agility, especially in the hospitalization units.

Benefits related to the social element of DT

For the interviewees, the benefits of DT can potentially increase *patient satisfaction* since several patient complaints are related to the time it takes to wait for a bed in emergencies and the surgical center. DT would decrease the waiting time, increasing the net promote score (NPS) indicator. This understanding is corroborated by previous research findings on the theme (Alam et al., 2020; Waring & Alexander, 2015, among others).

Some interviewees also mentioned benefits related to increasing *employee satisfaction*. A more agile and transparent process that allows for more asser-

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tive decisions reduces the stress on the collaborators participating in the bed management process. The perception is that the more technology is incorporated into the processes, the greater the relief in the collaborators' lives will be. As Haggerty (2017) identified, DT allows employees more access to patient data. Some interviewees also mentioned the increase in the satisfaction of the "medical client" who works in the institution due to the rise in the speed of the availability of beds. This aspect was not identified in the literature review.

According to the TF-IDF statistical analysis, the essential words for the social dimension are as follows: waiting time, patient satisfaction, patient transparency, lower time, better satisfaction, and medical client. These terms corroborate the benefits identified through content analysis.

Benefits related to the technological element of DT

These benefits are related to the *standardization of information* and to technology itself by the possibility of integrating the existing systems, as identified by Raffa et al. (2017). Some respondents believed that DT would allow for *more standardized*, reliable, and structured information available in real-time. For interviewee E10: "There is no management without indicators", and it is necessary to integrate all systems, thus corroborating with previous research (Williams et al., 2019; Abedian et al., 2018, among others).

According to the TF-IDF statistical analysis, the most important words for the technological dimension are as follows: manage, ease of use, there is an indicator, formed diagnostics, these indicators, and this monitoring. These words corroborate the benefits identified as technology's importance to obtain effective management through indicators.

The difficulties identified by managers are described in the next section.

Difficulties perceived by the managers

According to Figure 3, for the interviewees, the greatest difficulties in implementing DT are related to the *organizational culture* (mentioned 13 times during the interviews), followed *by technological difficulties* (mentioned 12 times), *process difficulties* (mentioned five times), *resistance from the doctors* (mentioned three times), *high investment* (mentioned three times), *patients* (mentioned two times), and *transparency, time, and information* (mentioned once each throughout the interviews).

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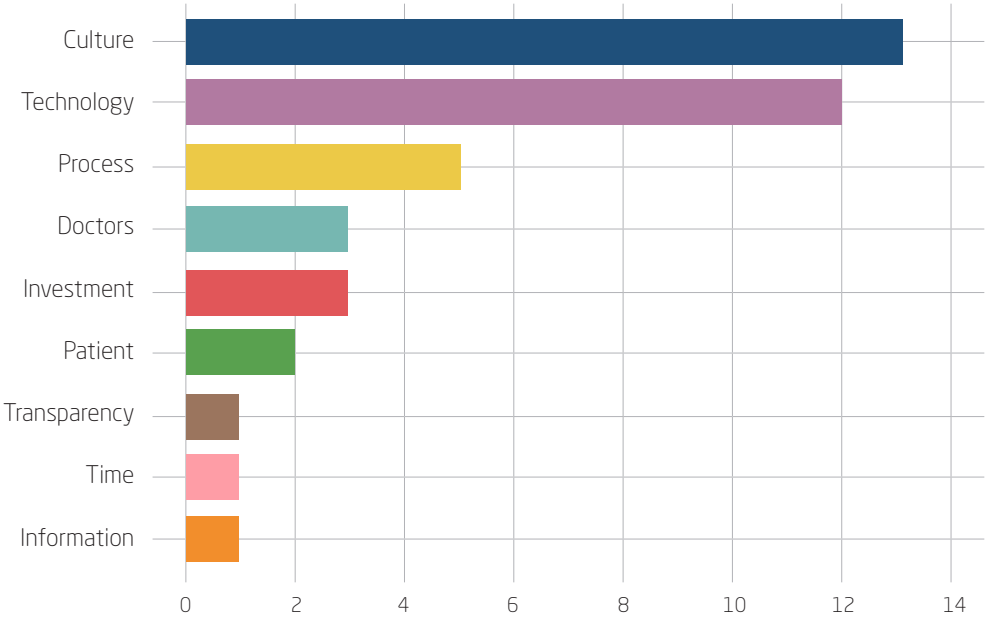
Figure 3

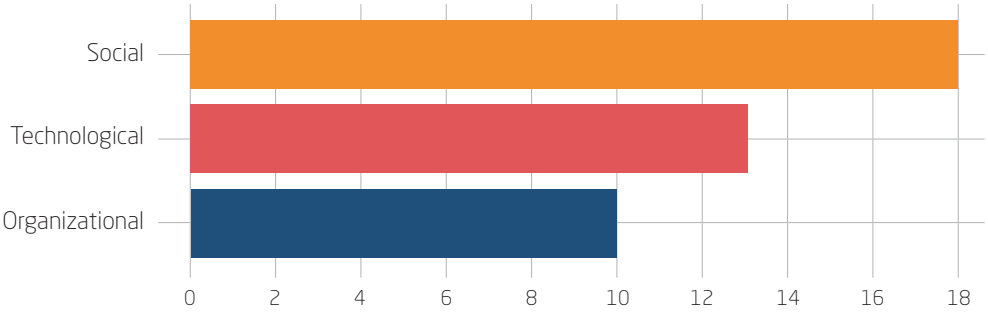
Main difficulties expected by respondents based on the frequency of citations during the interviews



When the difficulties are grouped into the three elements of analysis (Figure 4), the *social* element comes up as the greatest difficulty (mentioned 18 times), followed by *technological* aspects (mentioned 12 times), and finally, *organizational* aspects (mentioned ten times).

Figure 4

Frequency of answers related to the difficulties grouped by DT elements



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Implementation difficulties related to the social element of DT

The interviewees mentioned difficulties related to the *clinical staff*. Physicians would negatively perceive the new tool and highlight, for example, the failure to fill out the discharge forecast and the fear of losing control over the process. These difficulties were also reported by Hermes et al. (2020) when analyzing 1,830 health institutions. The interviewees also commented on the possible resistance by the collaborators to the changes needed, causing anxiety and resistance to the process. This result corroborates previous research (Alam et al., 2020; Sullivan & Staib, 2018, among others).

Essential words regarding the *social* element after assessing the difficulties identified by the managers through data mining and the TF-IDF calculation are as follows: was born like this, different today, people were born clinically, clinical staff, and we live with that. These terms highlight the possible impact of DT mainly on the hospital's clinical staff.

Implementation difficulties related to the technological element of DT

These difficulties involve the *interfaces and integrations* of the systems and data. The interviewees reported difficulty in customizing the information according to the department's needs and dealing with several versions of the same system in operation. These difficulties converge with those indicated in the literature (Raffa et al., 2017; Sullivan & Staib, 2018). According to E2: "A technological difficulty is sometimes that the system requires information that is not gathered 100% from the chain, so we have other systems connected, and integrating and coordinating all this information is difficult".

The following difficulties were also mentioned: real-time data acquisition, maintenance of existing systems, obtaining more fluid and available information, and difficulties in developing and implementing tools that do not adhere to the care routine. These challenges are also present in the studies by Hermes et al. (2020), Sullivan and Staib (2018), and Raffa et al. (2017). As for usability, E3 mentioned that

> […] these tools have to have good usability, be user friendly, and they have to be something quick and at hand because these people are in health care and their focus is to assist patients. Putting information into the system is something secondary for the health care team.

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The difficulties reported are also related to the high value of the *investment* in technology and the high cost and time for its implementation, which is in line with the findings of Sullivan and Staib (2018), Raffa et al. (2017), and Hermes et al. (2020).

The most important words regarding the *technological* element after assessing the difficulties identified by the managers through data mining and the TF-IDF calculation are as follows: big problem, in this tool, world of information, integration interfaces, integrations, accurate information, some problems, and real-time. The words reinforce the main difficulties mentioned previously, mainly regarding data integration and the provision of real-time information.

Implementation difficulties related to the organizational element of DT

Those interviewed believed that the biggest difficulty in implementing DT is related to the *organizational culture*, mainly due to the need to change existing processes. The literature corroborates this perception (Allen, 2015; Raffa et al., 2017).

The difficulties mentioned also refer to the implementation process itself of DT: difficulties in overcoming sectorization to implement a single control, how to deal with exceptions, and how to properly input data into the system. According to E3: "The biggest difficulty is that we have information, people inputting this information in real-time". The concern with adequate inputting of data into the system has been reported in several previous studies (Raffa et al., 2017; Abedian et al., 2014; Cameron et al., 2015, among others). The interviewees also mentioned the organizational problems that the *transparency* from DT can raise, as Sullivan and Staib (2018) described.

The most important words regarding the *organizational* element after assessing the difficulties identified by the managers through data mining and the TF-IDF calculation are as follows: use the tools, a few months, some bottleneck, some discomfort, someone to follow, changes will come, cultural issue, it is difficult, and cultural because. The words illustrate the difficulty in establishing and following new processes and the difficulties related to the changes that need to occur due to adopting DT.

The next section brings the study's main conclusions, limitations, contributions, and suggestions for future research.

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CONCLUSIONS

The main perceived *benefit* of applying DT to bed management is to increase the efficiency of the process, given the possibility of real-time information. DT would allow managers to make faster and more assertive decisions, reducing the number of idle beds and increasing the number of beds available for care and procedures. The managers interviewed also reported potential benefits for collaborators, patients, and the clinical staff due to the greater transparency of the process and the decreased waiting time for beds. Regarding the main perceived *difficulties*, the interviewees mentioned the need for a culture change to implement the DT process in the hospital, difficulties related to the credibility of the technology, the deployment time, and the need to transform the organizational processes.

The results of this research reveal that DT can positively impact bed flow management, allowing more efficient, controlled, and transparent processes. Still, for the implementation of DT to be successful, it is essential to contemplate the three elements analyzed in this study.

The *technological* element refers to the need to implement new technologies to make the data available in real-time and ready to help with decision-making. However, acquiring new technologies is not enough to successfully implement DT. The *organizational* element must be considered in the DT process because it is necessary to address organizational issues, especially those related to the processes, changing and redefining policies that have to do with the issues and behaviors of physicians and patients. The *social* aspect deserves attention because DT impacts people's lives, whether they be managers, collaborators, doctors, or patients, who can generate resistance to DT. Furthermore, the concept of DT must be widely disseminated in the institution so that a culture of continuous improvement through DT is built. In the hospital investigated, there was a lack of knowledge by the managers interviewed about what DT is and its possibilities.

The theoretical contribution is to assess the benefits and difficulties of implementing DT through its technological, organizational, and social elements. The study dialogs with the literature review by Reis et al. (2018), corroborating the findings of these authors and complementing them as it empirically investigates the application of DT in the specific context of bed management. In addition, this study deals with a subject that is still little explored, especially in developing countries. This study is also fundamental in the practical field because it reveals a path for hospital managers in adopting DT since using digital technologies for hospital bed management is still

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incipient. This study also contributes to society since the successful implementation of DT can bring more efficiency to bed management, increasing the capacity of hospital institutions and allowing more patients to be treated in both the public and private sectors.

Despite its contributions, this research has some limitations that must be explained. The case study's main limitation is its small basis for scientific generalization (Flyvbjerg, 2006; Yin, 2001). For this reason, there is no objective for generalizing the results for all hospital bed management flows. In addition, multiple case studies are preferable to single case studies. As already explained, the institution analyzed is a pioneer in the subject, and there was no other institution at the time of this research implementing DT in bed management, making it impossible to analyze more than one case. To mitigate this limitation, several institution units were researched to bring a holistic view of the theme. Another limitation of the method is related to the bias introduced by the researcher during the collection and analysis of the cases studied due to the difficulty in separating the variables involved in the events studied. In addition, the interviewee's responses are subjective. As previously mentioned, a triangulation of the data collected was done to reduce material and analysis subjectivity. Finally, this research investigated a hospital in the process of implementing DT, so the assessments of the benefits and difficulties made by managers are well anchored in their expectations.

Future research could focus on investigating hospitals that have already implemented DT in order to understand whether the managers' perception after the implementation is compatible with the findings of this research. Another interesting study would be measuring the main bed management indicators after the implementation of the DT to evaluate the effective gains from the implementation. Finally, because of some differences between the public and private sectors, it is also suggested to perform the same research in a public hospital to compare the views of the public and private managers regarding DT.

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APPENDIX

Interview script

Specific objectives established	Questions asked in the field work (interview script)
Understand how bed management is performed in the hospital.	1.1 How is the process of managing beds done in the hospital? 1.2 Is there a responsible area? (Kerpedzhiev et al., 2019; Baru et al., 2015). 1.3 How is the interface done of the Housekeeping (Cleaning) and Maintenance area with the bed management area for a bed to become open for use? (Raffa et al., 2017; Cameron et al., 2015). 1.4 How is the process of requesting beds done by the Emergency Care Center, Surgical Center (elective and emergency surgeries), Clinical Hospitalization, and Internal Transfers? (Barado et al., 2012; Cameron et al., 2015; Raffa et al., 2017). 1.5 What indicators do you monitor regarding the bed management process? (average length of stay, occupancy rate, replacement interval, bed rotation, mean time of bed availability after medical discharge?) (Raffa et al., 2017; Rocha et al., 2018).
Understand if DT has been applied to assist in the bed management flow.	2.1 What management tools do you use for bed management? (Barado et al., 2012; Landa et al., 2018; Dai & Shi, 2019). 2.2 Do you use real-time data? (Barado et al., 2012; Landa et al., 2018; Rocha et al., 2018; Abedian et al., 2018; Dai & Shi, 2019). 2.3 Do you consider the tools to be appropriate? Why? (Do they meet the needs of requests for a bed from Emergency Care, Surgical Center, elective hospitalization, internal transfers?)
Identify the perceived DT benefits in the control of the resources (structure) of hospital beds.	What are the perceived DT benefits in the control of the resources (structure) of hospital beds? (Reis et al., 2018)
Identify the perceived difficulties of implementing DT for controlling hospital beds.	What are the difficulties perceived when implementing DT for controlling hospital beds? (Reis et al., 2018)

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