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CASE STUDY

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The process of outpatient care of children and adolescents in a tertiary-level hospital specializing in pediatrics: A case study focused on identifying opportunities for improvement with the aid of modeling using BPMN

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Introduction: Business process management has gained importance in organizations for providing improved productivity and cost reduction, with process modeling being the central role. Usually, with reduced resources, the health area can benefit from good management of its processes.

Objective: To identify proposals for improvements in the process of outpatient care of children and adolescents in a tertiary-level—the most specialized and complex—pediatric hospital.

Methods: A bibliographic survey on the subject and a case study with in loco observation of the processes with semistructured interviews with the professionals involved were carried out. Alpha Hospital was chosen for this study, and the modeling of the process was performed using Business Process Model and Notation.

Results: Twelve relevant articles were identified. The "AS-IS" model of the process was obtained as a result and presents the existing 4 subprocesses (patient reception, preconsultation, consultation, and postconsultation). Specifically, the following improvement opportunities were identified: (a) process monitoring through indicators; (b) adequacy of the information system; (c) creation of service evaluation mechanisms; and (d) definition and application of training sessions for whenever a new professional begins working in a specific sector. The problem with the waiting time for patient care was also identified, but with no obvious solution; further studies should be carried to solve the problem.

Conclusion: The use of the business process modeling approach and process analysis allowed the hospital team awareness of the process and the identification of an improved set that can be helpful to Alpha Hospital or be used by other hospitals.

1 | INTRODUCTION

Business process management (BPM) combines knowledge from information technology and management paradigms (van der Aalst, 2004; Weske, 2007) and uses them to identify, design, execute, document, measure, and monitor business processes so that the desired results can be achieved (Association of Business Process Management Professionals [ABPMP], 2013).

Currently, BPM has gained importance in organizations because of its potential for improving productivity and reducing costs (van der Aalst, 2013). For the correct and efficient use of BPM, it is necessary to obtain an understanding of the processes, how they are applied in the context in which they are inserted, how many resources they consume, and which will be the expected results (Harrison-Broninski, 2010).

The combination of information technology with BPM paradigms can lead to large gains, such as time, input savings, and satisfaction,

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thus generating good final results at the sites in which they are applied (da Silva, Damian, & de Pádua, 2012; Maddern, Smart, Maull, & Childe, 2013; Paim, Caulliraux, & Cardoso, 2008; van der Aalst, 2004; Weske, 2007). Knowledge and constant updating of business processes are extremely important for organizations, including those in the health sector. This is highlighted by the main characteristics of health processes: the high degree of dynamism, high complexity, and multidisciplinarity (Rebuge & Ferreira, 2012). These organizations are usually characterized by numerous medical disciplines and specialized departments, making their processes dependent on interdisciplinary cooperation and coordination, and it is crucial in this type of environment to optimize processes (Lenz & Reichert, 2007) and to orchestrate the activities of the various functions. Therefore, in this sector, most decisions are complex, unique, and usually relate to the tacit knowledge of specialists (Manfreda, Kovacic, Štemberger, & Trkman, 2014).

Furthermore, it is important to highlight other important characteristic points of health processes: (a) existence of different and noninteroperable information and communication technologies; (b) the need for flexibility of their processes; (c) the need for efficient monitoring and improvement of resource use; (d) increasing complexity in the level of care; (e) decrease in resources; (f) increasing regulatory supervision; (g) the need for continuous improvement of services provided; and (h) increased patient satisfaction (Aguilar et al., 2008; Doosty, Yarmohammadian, & Ebrahimipour, 2014; Martinho, Rijo, & Nunes, 2015).

Thus, the promotion of BPM in health organizations is justified by providing the analysis and improvement of their processes as a means to improve the quality and efficiency of their care (Doosty et al., 2014; Rebuge & Ferreira, 2012).

In order to manage the processes, it is important to know them and analyze them from the initial event to the achievement of their results. Among the most common reasons an organization considers analyzing its processes (Jeston & Nelis, 2006) are (a) the existence of difficulties in managing processes, including inaccurate and/or conflicting information; (b) the need to reduce costs and increase productivity; (c) complexity of the products and services offered; and (d) lack end-to-end vision of the processes, duplication of tasks, and lack of standardization and clarity of responsibilities.

Process modeling is one way of analyzing a process, focusing on the description and visualization of processes (Askari et al., 2013), through the creation of externalized representations of current or future processes in a collaborative way. A few papers focus on the challenge of process analysis through health sector modeling (Askari et al., 2013; Manfreda et al., 2014); therefore, the question we wish to answer with this study is "What are the opportunities for improvement in an outpatient care process for patients in a tertiary-level pediatric hospital that can be identified through process modeling?"

Therefore, this study aims to contribute to the characterization of this type of process in Alpha Hospital and identify all the professionals involved in the process, the opportunities for improvements in the care of their patients, and the management of the process as a whole. In addition, researchers and practitioners may benefit from the results of this study either by practical use of the processes and solutions or by developing further studies.

The next section summarizes the theoretical reference used for the elaboration of this research. Section 3 describes the methods used in the case study, consisting of the factual survey and the characterization and modeling of the patient care process and its subprocesses in order to identify opportunities for improvements. Section 4 sums up the most relevant publications in the field and presents the resulting process model and the improvement opportunities identified in the chosen hospital. Section 5 discusses the results obtained and the main limitations of the study. Finally, the last section, the sixth section, presents the conclusions of the article, taking into account contributions and possible future work.

2 | BACKGROUND

With a central role in process management, business process modeling aims to describe the different ways in which a process instance can be manipulated, providing subsidies for management to reduce costs while improving service delivery, and, consequently, improve the operational business processes (van der Aalst, 2013). The central concept of modeling is the creation of a representation of the processes' functioning that can achieve the organizational objective, describing the activities involved and how these relate to or interact with each other, with other processes and with the necessary resources (ABPMP, 2013; Aguilar et al., 2008).

Modeling a process also provides benefits to its actors, as it helps them understand the process as a whole and the interdependence between activities. It also helps in understanding the specific requirements of their work environment, and which tools are most appropriate for the process. The execution of their activities allows greater awareness about their role and responsibility in the process and provides greater possibility of visibility and recognition for the work they perform (ABPMP, 2013). Thus, process actors should also be an integral part of modeling, analyzing, and improving a process through sociotechnical approaches that include important aspects for these actors, such as their satisfaction, their needs, their appropriate training, and their need for continuing education (ABPMP, 2013; Aguilar et al., 2008; Berg, 1999).

Modeling can be expressed according to the level of complexity of the process or the vision that needs to be represented, performed by different techniques, and presented in different languages (ABPMP, 2013; Dufresne & Martin, 2003). Thus, the way the process will be studied will define the choice of the most appropriate technique or language (Dufresne & Martin, 2003). Some of the most used languages are Flowcharts, Integrated Definition Language, Unified Modeling Language, and Business Process Model and Notation (BPMN).

BPMN is a graphical language standard for representation of business process modeling, defined and maintained by the Object Management Group. BPMN was conceived to be understood by technical and nontechnical professionals of the work team and is the most used language for representing the process flow (Object Management Group, 2011). Another advantage of its use is the speed that conceptual models elaborated with such notation can be converted into executable languages (Onggo, 2014).

Modeling of a process allows the identification of opportunities for improvement related to interactions with stakeholders, handoffs, bottlenecks, variations, human considerations, cost, business rules, and activities with added value (ABPMP, 2013; Weske, 2007).

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In the health area, process modeling aims to facilitate the understanding and visualization of how activities are performed with focus on the organization's mission and patient care, as well as identification of the logical sequence of processes and their efficiency (Aguilar et al., 2008). Some examples of the use of process modeling in the health sector are (a) modeling and simulation of processes for analysis and improvement of operational performance (Bisogno, Calabrese, Gastaldi, & Levialdi Ghiron, 2016); (b) application of process modeling for distributing and dispensing drugs in a surgical center of a large Brazilian hospital to comply with new federal regulations (Pereira, Tonani, Somera, da Costa, & de Pádua, 2016); (c) elaboration of a flowchart model of the patient path in a pediatric emergency (Ajmi et al., 2015); (d) modeling of the kidney transplant process in Brazil (Penteado et al., 2015); (e) implementation of BPM in an Iranian hospital and the verification of the efficiency of such implementation in the hospital (Doosty et al., 2014); (f) proposal of a methodology for analyzing health processes through data mining and validation techniques in a hospital in Portugal (Rebuge & Ferreira, 2012); and (g) the impact of workflow management systems on the development of hospital information systems (Graeber, 1997).

Real-time monitoring and follow-up of the processes are possible through the use of wireless sensing systems in clinical settings, in particular, to monitor (a) patients waiting for care, (b) peak attendance situations, (c) intrahospital transport of patients, and (d) pediatric patients (Ko, Gao, Rothman, & Terzis, 2010).

In industrial process modeling, the main goal is to minimize the task and the processing time as a whole by maximizing quality, but in the specific case of health process modeling, it should be noted that a greater perception of contact time with health professionals is associated with a higher degree of service satisfaction (Cape, 2002).

3 | METHODS

To achieve the objectives of this study, a literature review of related works was initially carried out. This survey consisted of searches in bibliographic databases using the following script: (a) use of the Google Scholar (http://scholar.google.com/), PubMed (https://www.ncbi.nlm.nih.gov/pubmed), Scopus (https://www.scopus.com/), and IEEE Xplore (http://ieeexplore.ieee.org/Xplore/home.jsp) databases; (b) combined use of the following keywords: “business process,” “modeling,” “health,” “healthcare,” “hospital,” and “pediatric”; (c) filtering articles from scientific journals, conference publications, and books or e-books after the year 2000; (d) textual analysis of the abstracts of the article, identifying those with a higher degree of relationship with the objective of this study; and (e) analysis of the selected articles.

This is a case study carried out in a tertiary-level hospital—the most specialized and complex level—focused on pediatrics with the objective of identifying improvements in the process of outpatient care. The case study is a research method whose choice occurred because of the need for a comprehensive holistic approach and for enabling a better understanding of the complexity and singularity of specific organizational phenomena (Feagin, Orum, & Sjoberg, 1991; Simons, 2009; Yin, 1994). Alpha Hospital is a tertiary-level university hospital located in the interior of the state of São Paulo in Brazil. It was created to provide more appropriate treatment for children and adolescents in various specialties and presents in its physical space the functions of outpatient care, nursing, obstetric center, neonatal intensive care unit, pediatric intensive care unit, joint accommodation, and center for surgery and epilepsy.

Therefore, the case study protocol that guided the execution of this case study was defined and can be visualized in Table 1.

The second step consisted of the characterization and modeling of the process of outpatient care at Alpha Hospital. One method commonly used to characterize and gather as much relevant information about the process is interviews. Interviewees can include clients, suppliers, and business partners, those who work directly with the process and who provide inputs or receive outputs of the process. These interviews can be face to face, by telephone, web conferencing, or email (ABPMP, 2013).

In this case study, the process characterization was performed from semistructured interviews and observational analysis in loco with the management and operational professionals involved in this process, including the coordinator of the medical team and operational and administrative managers. The main objective of these interviews was to identify the activities performed during outpatient care, the information systems involved in the process, and the opportunities for improvement perceived by the professionals.

The interviews were carried out following a road map that covered the following questions: (a) What activities are involved in the process; (b) who performs each activity; (c) how each activity was performed in the context of the process; (d) where each activity was performed; (e) when each activity was performed in the context of the end-to-end process; (f) why each activity was carried out in the process in question; and (g) how was the use of the information system during each activity.

An initial representation of the process was made using BPMN version 2.0.2 through Bizagi Process Modeler version 2.7.0.2 software.

The third step was composed of new interviews with the same professionals previously interviewed. These interviews aimed to refine the initial modeling by obtaining more information about the analyzed process and to gather information about possible problems and possibilities of improvements in the execution of the process that could provide better care during patients' attendance. These interviews took place following a predefined script, elaborated based on the knowledge obtained from the operation of the process, and in their composition were questions on the following topics: interactions with stakeholders, hand offs, bottlenecks, variations, human considerations, cost, business rules, and activities with added value (Weske, 2007; ABPMP, 2013).

Thus, a presentation was made with the main stakeholders of the process for validation of the elaborated model, exposure of the identified improvement opportunities, and critical analysis of the results found. As a result, it was possible to obtain (a) the modeling of the process in its current configuration (“AS-IS” model) using BPMN and (b) an improvement opportunities report for the process.

The interviews conducted in the second and third stages occurred during the period of March to July, 2016.

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TABLE 1 Protocol of the Case Study

Research question	What are the opportunities for improvement in an outpatient care process for patients in a tertiary-level pediatric hospital that can be identified through process modeling?
Unit of analysis	Process of outpatient care in a tertiary level hospital specializing in pediatrics
Time limits	Between March and July, 2016
Location	Alpha Hospital specializing in pediatrics
Validity of constructs	Theoretical-practical contrast, based on literature review
Internal validity	Observation Documents Interview with medical team coordinator, operational, and administrative managers as a source of evidence
Elementary questions from the case study	What are the activities performed in the process? Can each process activity be improved? How can process modeling help with management? How can process modeling help to diagnose opportunities for improvement? What is the expected impact of the identified improvements in the information systems?

4 | RESULTS

The literature review was carried out in the databases previously mentioned using the following terms: "business process modeling"; "business process modeling" + "health"; "business process modeling" + "healthcare"; "business process modeling" + "hospital"; "business process modeling" + "pediatric"; "health business process"; "healthcare business process"; and "hospital business process." Even with filtering the publications by year and type of document, a large number of articles were obtained. A summary of these results can be seen in Table 2.

From the analysis of the abstracts of the articles, it was possible to identify 12 key articles for this study. Table 3 presents a summary of these articles in order to present their authors, title, objectives, applied methods, and main results.

Another result of this work was the identification of how the outpatient care of children and adolescents in Alpha Hospital is carried out by the construction of a representative model of the current state of the process (AS-IS model) using BPMN. The summary view of the AS-IS model containing the process representation and its subprocesses can be found in Figure 1, and the description of this process will be performed in the following paragraphs.

The current Alpha Hospital outpatient care process can be divided into four steps: patient reception, patient preconsultation, patient consultation, and patient postconsultation.

In the first stage, the patient and their companions are received in the main entrance of the hospital, where their entry is confirmed and then directed to the attendance area of Alpha Hospital. This entry occurs after verification in the hospital information system of the existence of a scheduled appointment, or in specific cases such as new case referral guide, missed appointment, need to change scheduled appointment, and patient status severity. The verification of the consultation schedule is made at the Alpha Hospital outpatient care reception, and the patient's presence is recorded in the information system. It is also at this moment that the patient's record and the consultation card are created if the patient does not already have them. Thus, the patient is referred to the waiting room until being called on electronic panels. On these panels, the patient's name and photo are displayed along with the room where the patient has to go. Finally, the consultation card is taken to the prescription room, and, if requested by the medical team of the specialty in which the patient is treated, the patient's physical medical record is also sent, because the hospital already has an electronic medical record. This step can be seen in Figure 2.

TABLE 2 Summary of the number of the scientific articles found

Database	Keywords	Occurrences
Google Scholar	Business process modeling	16,700
Google Scholar	Business process modeling; health	5,500
Google Scholar	Business process modeling; healthcare	2,630
Google Scholar	Business process modeling; hospital	2,120
Google Scholar	Business process modeling; pediatric	81
Google Scholar	Health business process	48
Google Scholar	Healthcare business process	127
Google Scholar	Hospital business process	100
IEEE Xplore	Business process modeling	3,177
IEEE Xplore	Business process modeling; health	406
IEEE Xplore	Business process modeling; healthcare	235
IEEE Xplore	Business process modeling; hospital	205
IEEE Xplore	Business process modeling; pediatric	11
IEEE Xplore	Health business process	3
IEEE Xplore	Healthcare business process	17
IEEE Xplore	Hospital business process	7
PubMed	Business process modeling	24
PubMed	Business process modeling; health	19
PubMed	Business process modeling; healthcare	5
PubMed	Business process modeling; hospital	8
PubMed	Business process modeling; pediatric	0
PubMed	Health business process	0
PubMed	Healthcare business process	0
PubMed	Hospital business process	0
Scopus	Business process modeling	10,647
Scopus	Business process modeling; health	970
Scopus	Business process modeling; healthcare	709
Scopus	Business process modeling; hospital	453
Scopus	Business process modeling; pediatric	25
Scopus	Health business process	23
Scopus	Healthcare business process	41
Scopus	Hospital business process	13

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TABLE 3 Summary of scientific articles used as theoretical reference

Author(s)	Year	Title	Objectives	Methods	Results/conclusions
Aguilar et al.	2008	Process modeling of the health sector Using BPMN: A case study	Application of BPMN in the modeling processes in the health sector so that the experience obtained can be applied to any health institution.	The applied research method was research action, and the work was carried out in different stages. These stages consisted of the formation of two study groups in different hospitals, meetings with the management and operations teams to delimit the study and to learn modeling techniques (BPMN), identification of all processes and choice of those of interest, modeling one of the chosen processes, and intragroup and intergroup validation of the resulting model.	The resulting model is shown for the surgical patient process, presenting in an abstract way the actors, activities, and the means of communication involved. From this model are presented the situations that have improved or not the execution of the service to exemplify the gain that can be had from the adoption of BPM in an organization of the health sector. From the experience obtained, it has been demonstrated that BPM is easy to apply, can be easily applied in another field, and can be simultaneously understood by all process users. The work presented in this article was the starting point for the development of models of the processes that the institution considers most important to fulfill its mission. In addition, this will create reference models that will serve as a basis for the organization to certify between hospital improvement programs, process analysis and redesign, evaluation of process efficiency, elaboration of information systems, among others.
Ajmi et al.	2015	Mapping patient path in the Pediatric Emergency Department: A workflow model driven approach	Elaboration of a methodological approach for the anticipation of crowding situations in complex care systems, specifically on emergency routes in a French pediatric emergency hospital. It also aims to present pediatric emergency procedures and detailed data on all aspects of the patient's journey to identify indicators of crowding situations and bottlenecks that contribute to overcrowding.	Observation of the execution of the patient's journey process in the Pediatric Emergency Department and interviews with the team. Validation of the observations in a team meeting and then elaborate a process model using BPMN. Execution of simulation of the process model and comparison with real scenarios of the patient's paths, seeking model optimization.	The major source of delay in patient flow is waiting in line, specifically due to room release before discharge from pediatric emergency, accounting for 70% of the patient's occupancy time in emergency waiting rooms. The use of actual data to construct the patient flow model is effective in identifying sources of delay and aspects of pediatric emergency activities that can be improved. The development of this model was based on visits made to a French regional hospital. It allows the identification of pediatric emergency dysfunctions and to propose and estimate preventive indicators of crowding situations.
Amin and Nasharuddin	2013	Hospital service quality and its effects on patient satisfaction and behavioral intention	Investigate the quality of the hospital service and how it affects patient's behavioral satisfaction and intention.	Use of convenience sampling for the delivery of questionnaires among patients who were hospitalized and discharged from public or private hospitals in Malaysia. The questionnaires measured three categories: quality of hospital service, patient satisfaction, and behavioral intention.	The results confirmed that admission, medical service, general service, discharge, and social responsibility constitute the dimensions that build the quality of the hospital service. Establishing high-quality levels will lead to high consumer satisfaction and behavioral intent. Thus, managers should use perceived service

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TABLE 3 (Continued)

Author(s)	Year	Title	Objectives	Methods	Results/conclusions
					quality and consumer satisfaction as mechanisms that enhance the loyalty of their current patients. However, the study did not explore the perspective of service providers, focusing only on the patient's vision.
Bisogno et al.	2016	Combining modeling and simulation approaches: How to measure performance of business processes	Provide a method for analyzing and improving the operational performance of business processes.	The proposed method employs modeling (BPMN) and simulation (Business Process Simulation Interchange Standard - BPSim 1.0) of processes to measure performance indicators and test potential improvements. The process is initially modeled so that the operational performance measurement can be performed through simulation. To validate the method, a case study is performed to examine the process of arrival and treatment of patients in a pediatric emergency in a public hospital.	The results presented the framework used and how it was applied in a case study. Thus, the methods allow the detection of process criticalities and identification of the best corrective actions by a "what-if" analysis. The research and management implications by using the methods were also discussed. It also provides the steps for process modeling and simulation that serve as a "virtual lab" to test for potential improvements and their impacts on operational performance without the risk of error.
Cape	2002	Consultation length, patient-estimated consultation length, and satisfaction with the consultation	Test the hypothesis that the patient's perception about the time of consultation is influenced by other aspects of their consultation experience and not only about the time of consultation.	Correlation analysis of surgical patients from 18 to 75 years of nine general practitioners. The data were obtained for a sample of patients through the General Health Questionnaire, recording the subsequent consultation to measure the time of the consultation. After 5 days from the consultation, another interview and application of a questionnaire to estimate the patient's perception about the duration of the consultation and their satisfaction were made. The relationships between the variables were performed via correlational analysis and *t* test using SPSS software.	Consultation satisfaction of the patient was related to overestimation of the duration of their consultations. Patients' concerns about time can be as much related to real time as to quality time. This is consistent with the hypothesis that the perception of time is influenced by other aspects of the consultation experience than only time. However, the study has several limitations and possible alternative explanations for the results.
Doosty,		Yarmohammadian and Ebrahimipour	2014	Improvement of hospital processes through business process management in Qaem Teaching Hospital: A work in progress	Presentation of a BPM approach in the health sector to enable better organization and to review its critical business processes.
The project scope included selection of three to five preferred processes by a process improvement committee. It took place in Iran's Qaem Teaching Hospital and had four distinct steps:	The	results obtained were documentation regarding the prioritization of the processes, the stakeholders involved, and the improvement plan for three processes. The adoption of BPM in the hospital changed the nature of management by allowing the organization to avoid			

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TABLE 3 (Continued)

Author(s)	Year	Title	Objectives	Methods	Results/conclusions
identifying business processes, documenting processes, analyzing and measuring processes, and summarizing and finalizing documentation and improving processes.		the complexity of disparate systems. Instead, BPM allowed the organization to focus on business processes at a higher level.			
Ko et al.	2010	Wireless sensing systems in clinical environments: Improving the efficiency of the patient monitoring process	Presentation of the development of the wireless monitoring system (MEDiSN) for tracking vital signs of outpatients and showing their usages to understand the challenges associated with wireless sensing systems (WSS) applications in hospital environments.	Introduces WSS technology applications for hospital environments, along with key deployment challenges. Pilot test of the developed application, which took place in the Emergency Department of Johns Hopkins Hospital. The pilot monitored the waiting time for emergency patient consultation.	It presents the applications of WSS technology for hospital environments (monitoring of waiting patients, monitoring of peak care situations, intrahospital transport monitoring, and pediatric patient monitoring), along with the main challenges of its implementation (support for large-scale networks and network expansion, high data rate networks, patient mobility, patient location, real-time data delivery independent of the route, and safety). It also examines the potential of this technology in improving the efficiency of the patient monitoring process in clinical settings. It also presents possible technical challenges for its large-scale deployment. The application developed has a high degree of tolerance to human mobility and was well received by patients and staff members of the hospital. Thus, validation of the application shows that it can successfully perform monitoring of vital signs of patients waiting for care.
Lakshmi and Appa Iyer	2013	Application of queuing theory in healthcare: A literature review	Describe the main trends in the application of queue model theory that are available to health decision makers, taking into account that the resulting bibliography should not be considered as final.	Using the operational research model, a review of the literature was conducted in search of articles describing queue models and their topics, or key words, related to population health problems. Subsequently, the selected articles were assigned to areas according to application area and modeling method. Due to the quantity of articles obtained, only those published in the years 2000 or later were selected for analysis.	Articles published with reference to the application of queuing theory in the health sector, specifically in the modeling of hospital processes, were searched in the literature, reviewed, and categorized, resulting in 141 articles for review. The main areas identified are healthcare systems design (outpatient care, hospital, and pharmaceutical services); healthcare systems operation (resource scheduling and patient scheduling); and healthcare systems analysis (waiting time and utilization analysis and queue length/limited queue discipline/blocking, and minimize costs). There were articles from 1952 to 2011, with a greater number

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TABLE 3 (Continued)

Author(s)	Year	Title	Objectives	Methods	Results/conclusions
					starting in the year 2000, something that may be related to the increase in the supply of software and advances in computational power. Such a review also cannot be considered exhaustive, but it provides several insights on the use of queuing models for health management. Thus, the article was considered as a reference source for other researchers/readers interested in the application of queuing theories in health management.
Martinho, Rijo and Nunes	2015	Complexity analysis of a business process automation: Case study on a healthcare organization	Case study for the impact analysis of the implementation of a new medical consultation scheduling system Information and Communication Technology (ICT) in a large hospital in Lisbon, Portugal.	Three processes were modeled using BPM before and after the implementation of the new system. Metrics of process complexity (design time) were used to measure the impact of the system, considering the affected processes. Then, a comparison between the old and the new processes was performed not only to analyze the differences but also to conclude on the adequacy of such metrics in relation to the level of impact observed with the introduction of the new system.	The results show that the new scheduling system did not have much influence on the number of activities among the three analyzed processes, with small oscillations depending on the type of activity and process evaluated. The conclusions derived from the results were that the metrics helped to discover that the new processes remained similar to the old and that the new system did not bring down the complexity of the processes. Also, the main return observed in the field by the introduction of the new system into the processes cannot be observed using abstract complexity measures, and it is necessary to analyze the processes using performance metrics, such as the number of medical consultations scheduled per day and the occupancy rate of certain examination equipment. As future work, a complete complexity analysis is visualized through the use of metrics in the processes data retrospectively and the need to observe a possible optimization brought by the system in other processes subsequent to the appointment scheduling, such as the medical consultation process and the attendance/absence rate.
Penteado et al.	2015	Kidney transplantation process in Brazil represented in Business Process Modeling Notation	Analysis of official documents for the representation of the kidney transplant process in Brazil using BPMN.	The methodology was based on exploratory and observational study, analysis of documents, and construction of process diagrams with the use of BPMN. In addition, specialists conducted two validation rounds.	The results include BPMN representation of the kidney transplant process in Brazil, composed of two processes with a total of 45 activities and events, involving six organizations and six different stages of the process. Building the process representation has made it easier to understand

(Continues)

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TABLE 3 (Continued)

Author(s)	Year	Title	Objectives	Methods	Results/conclusions
					the business rules of kidney transplantation and can be used by healthcare professionals involved in various activities within the process.
Pereira et al.	2016	Application of modeling in a drug distribution and dispensing process focused on traceability in a surgical center	To present a case study of a model application for distributing and dispensing of drugs process in a surgical center of a large hospital in Brazil, in order to comply with the new federal regulations.	Conducting the case study in a tertiary-level university hospital to perform the comparison between theory and practice from the state of the art theme. Local observations, document analysis, and interviews with business managers were carried out to obtain the data.	Process modeling allowed the characterization of the current distribution and dispensing of drugs in the surgical unit. The proposed improvement design considers the current limitations and opportunities for improvement identified for the current situation. The proposal presented allows the implementation of legal requirements for the traceability of medicines. The use of modeling for process redesign was of great help in developing and evaluating the necessary changes, as well as promoting a broad discussion about the current process and proposed improvements, reducing the risk of failure when implementing the new work process.
Rebuge and Ferreira	2012	Business process analysis in healthcare environments: A methodology based on process mining	Elaboration of a methodology for analysis of business processes based on process mining. This methodology includes data-mining techniques relevant to the characteristics of health processes. To validate the methodology, a case study was conducted in a Portuguese public hospital through the construction of a tool that implemented such methodology.	The proposed methodology is composed of the following steps: (a) preparation of an event record, (b) inspection of the registry, (c) sequence clustering analysis, (d) flow control analysis, (e) performance analysis, (f) organizational analysis, and (g) transfer of results. A case study was carried out in a Portuguese public hospital to validate the methodology.	The proposed methodology includes the calculations and procedures present in each step. In the execution of the case study, it was decided to limit the scope in the flows of emergency patient care, and whose activities include screening, treatment, diagnosis, medical examination, and referral of patients. The tool produced obtains data from the hospital information system and provides a set of process-mining techniques for analyzing the selected health process. The application, called the Medtrix Process Mining Studio, implements the methodology where the clustering sequence plays a major role in identifying regular behavior, process variations, and nonfrequent behavior. Thus, the application was used for the selected data resulting in clusters of information to be analyzed. Such analyses occurred as a whole and by sectors (performance analysis of the radiology flow and organizational perspective of the emergency care flow). The tools and results are specific to the case study but can be adapted for use in other health environments.

Note. BPM = business process management; BPMN = Business Process Model and Notation.

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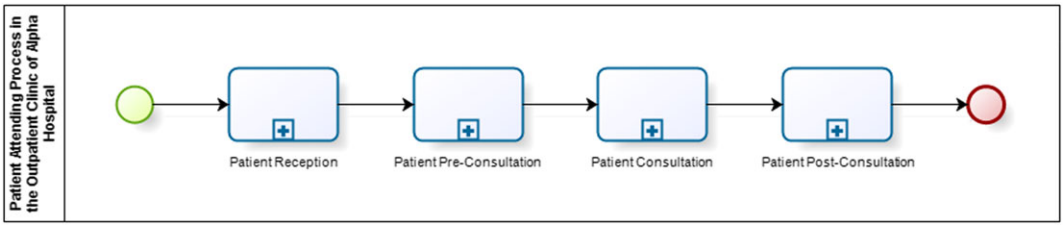

FIGURE 1 Representation in Business Process Model and Notation of the current state ("AS-IS" model) of the Patient Attending Process in the Outpatient Clinic of Alpha Hospital [Colour figure can be viewed at wileyonlinelibrary.com]

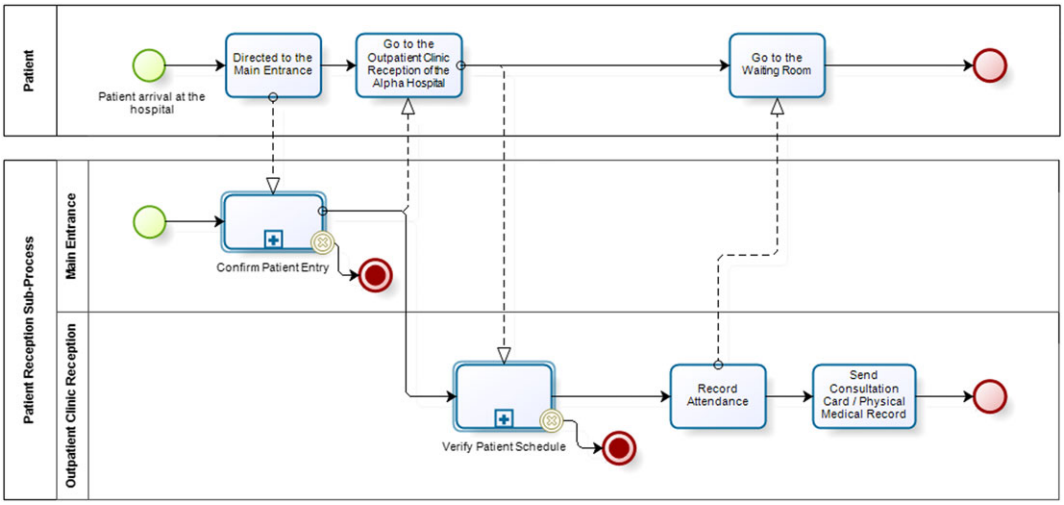

FIGURE 2 Representation in Business Process Model and Notation of the patient reception subprocess of the current state ("AS-IS" model) of the Patient Attending Process in the Outpatient Clinic of Alpha Hospital [Colour figure can be viewed at wileyonlinelibrary.com]

The second stage refers to the preconsultation and consists of the biometric examination of the patient. The performance of such examination is dependent on the specialty in which the patient will be attended. If it is mandatory to perform, the patient will be called via an electronic panel to attend the biometrics room. During the examination, the biometric data are obtained by the nursing team and registered in the information system. After this, the patient will be instructed to wait in the waiting room for the call for the appointment. This step can be seen in Figure 3.

The third stage refers to the medical care itself. It begins with the doctor choosing the patient to be attended, according to criteria of priority and in chronological order of arrival. After choosing the patient, the doctor makes an analysis of the patient's previous medical records, whether physical and/or electronic file, and then makes the call through the information system. Only then is the patient notified by the electronic panel to go to the doctor's office. Because Alpha Hospital is a teaching hospital, attendances occur by medical students in their fifth or sixth year, resident physicians, hired doctors, and/or teaching physicians. If the care is performed by resident or medical students, a case discussion with the supervising medical doctor is necessary before the consultation is concluded. Then, if necessary, exams are ordered, medications are prescribed, and the patient's return

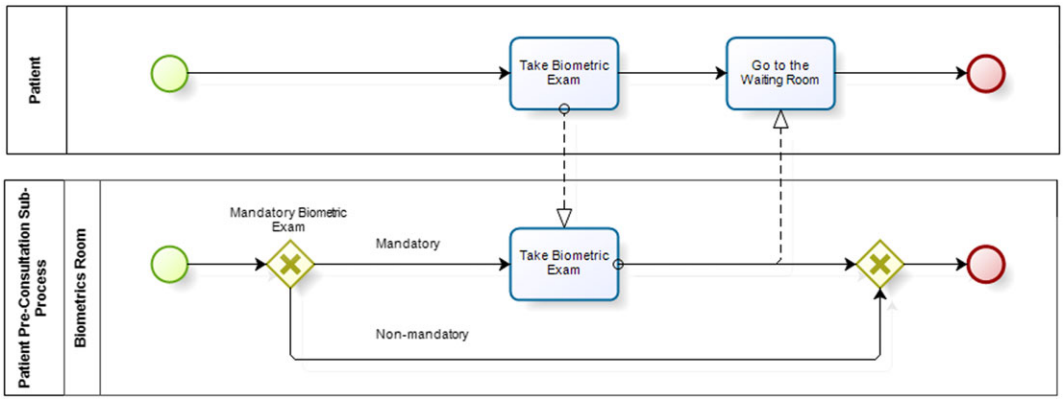

FIGURE 3 Representation in Business Process Model and Notation of the patient preconsultation subprocess of the current state ("AS-IS" model) of the Patient Attending Process in the Outpatient Clinic of Alpha Hospital [Colour figure can be viewed at wileyonlinelibrary.com]

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schedule is performed. At the end, all information is transmitted by the doctor to the patient, and the documents generated in the consultation are delivered before the patient is released and sent to the postconsultation. This step can be seen in Figure 4.

The fourth and final stage refers to the postconsultation, which includes the nursing staff attending the patient after leaving the doctor's office. In this step, the information regarding examinations, medicines, and patient's return schedule is once again passed on to the patient and then reinforced. The patient is then referred to the hospital reception for delivery of the medical record, if there was any, and to confirm in the information system if the return schedule is the same as that registered in the patient's appointment card. The patient is then able to leave the hospital. This step can be seen in Figure 5.

It should also be noted that it was necessary to define the level of detail of the presented model and to make decisions about the selection of the steps to be included in the process. Therefore, it was decided to consider the steps that add greater value to the process and that were considered relevant by the stakeholders.

Another result obtained was the elaboration of a report on opportunities for improvement based on the information obtained in the interviews and on the refined version of the process model. Through these interviews, it was identified that one of the major problems of the process is related to the long waiting period by the patients to receive medical care (bottleneck) and both professionals and patients reported this. This problem has several causal factors, some of them related to the way patients are taken to the hospital, appointment schedules, changes in the form of care according to the medical specialty, prioritization of patient care, among others. Some solutions have been implemented by the hospital, such as expanding the use of electronic medical records and staggering the appointments in some specialties, but the problem has not been completely solved. Hence, the resulting report failed to indicate a permanent solution to the problem, with further studies focused on resolution being necessary.

During the development of the modeling, it was also possible to verify that the interviewers evaluated the amount of activities, physical and human resources, and the number of interactions as adequate. Even with the existence of redundant activities in the process, they did not classify them as problems, but rather as necessary for better patient care.

Another point identified is that there is no constant monitoring of the process by indicators and that only semiannual or annual evaluations are carried out. Thus, one of the improvement suggestions presented in the report would be the creation of specific and standardized trend and occurrence indicators by task cycle (ABPMP, 2013) that would allow the hospital manager to perform constant monitoring of care and therefore result in a faster identification of possible problems in the execution of the process.

Alpha Hospital makes use of a single computerized information system, the functionalities of which are based on specific modules and with a small degree of interoperability between such modules. It was verified that such a system presents some flaws, namely, the lack of information on the stage of the process the patient is in, the nonuse of the system to control the ordering of attendance, and the use of the system only for storing information. Thus, with the resulting model, new requirements were identified in the information system that can assist even more in the process execution and monitoring.

Another suggestion for improvement would be the creation of standardized mechanisms for evaluating the service provided, so that

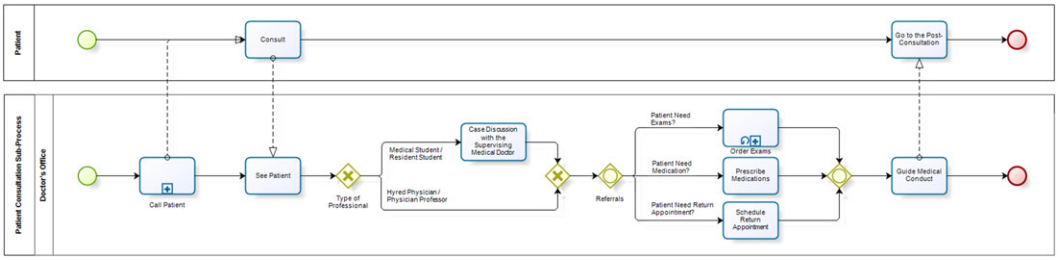

FIGURE 4 Representation in Business Process Model and Notation of the patient consultation subprocess of the current state ("AS-IS" model) of the Patient Attending Process in the Outpatient Clinic of Alpha Hospital [Colour figure can be viewed at wileyonlinelibrary.com]

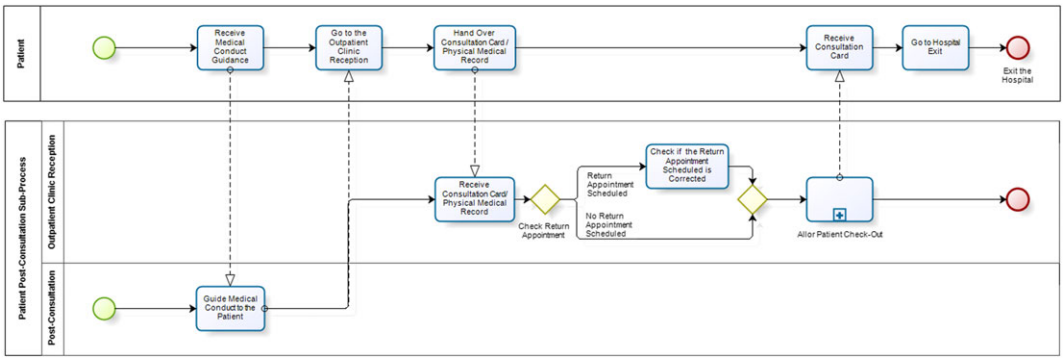

FIGURE 5 Representation in Business Process Model and Notation of the postconsultation subprocess of the current state ("AS-IS" model) of the Patient Attending Process in the Outpatient Clinic of Alpha Hospital [Colour figure can be viewed at wileyonlinelibrary.com]

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patients could make complaints, suggestions, and compliments, something that currently occurs informally and segmented to hospital sectors. It is worth mentioning that there is a patient ombudsman program in the hospital that enables contact via email, telephone, or in writing in specific places of the hospital but there is not yet an appropriate place to collect this information at the Alpha Hospital outpatient clinics and reception.

The final proposal for improvement is the establishment of training sessions focused on the activities performed at Alpha Hospital whenever a new professional begins to work in a specific sector. This training would aim to clarify how the specific processes and procedures are performed in Alpha Hospital and how the information system should be best used.

5 | DISCUSSION

van der Aalst (2013) points out that business process modeling plays a fundamental role in the management of an organization by assisting in the knowledge of the process structuring, aiming at cost reduction and improvement of the service provided. In this context, by the on-site analysis and the modeling of the outpatient care process in the case study performed, some important points were identified for the proper functioning and execution of the process, with the main point of dissatisfaction indicated by management was the waiting time until patient care occurs.

Another situation that deserves attention in patient care is the duration of the interaction between the health professionals and patients. Given the specific characteristics of a teaching hospital, duration of care is usually greater at Alpha Hospital in comparison with a nonteaching hospital, which can be considered as a bottleneck by some of the managers. Cape (2002) concluded that the perception of patient satisfaction is related to the perception of the time of contact with health professionals. Thus, the greater the contact time, the perceived quality of care is considered better. In this context, further studies are needed to reformulate the process in order to increase the time of contact with health professionals and reduce waiting times.

Opportunities for improvement have been identified regardless of the health information systems. There is a significant opportunity for interoperability as the software used is created and maintained with the hospital's own standards, restricting the exchange of data with other levels of the healthcare network. This exchange could allow the optimization of resources by avoiding repetition of previous procedures or examinations. Another point of suggestion for improvement of the system is that once the care process is started, it is possible to know the exact location of the patient. This type of information can be useful, for example, if a specific patient has more than one specialty scheduled for the same day, because it is currently not possible to know in which specialty they are at any moment during his or her care. Tracking the location of patients is important not only during the transport of patients who are hospitalized or cared for in the hospital but also simplifies the process of locating patients in the waiting room. This tracking would reduce the workload of healthcare professionals and improve the efficiency of the patient care workflow (Ko et al., 2010).

An important measurement instrument to be adopted by Alpha Hospital would be to record the times of each patient at each step of interaction in the process. Its availability in real-time and in an accessible way to the entire team would make the management of the process performance and changes related to these aspects quicker and more accurate, as well as providing a view of each service as a whole.

Training sessions and workshops with health professionals, who are process actors (ABPMP, 2013), are other circumstances that deserve attention as an improvement, possibility because due to the characteristics of the hospital, the workload of its staff is very high. This action could be planned and performed using sociotechnical approaches (Aguilar et al., 2008; Berg, 1999).

Regarding the way consultations are scheduled, the management of Alpha Hospital consider that the staggering of the appointment schedule may not be so relevant because the majority of patients come from other municipalities in the region and have their arrival regardless of the time of the consultation. However, according to the work of Lakshmi and Appa Iyer (2013) and Amin and Nasharuddin (2013), the perception of good service is inversely related to waiting to receive the aforementioned service after the scheduled time; that is, regardless of when the patient arrives at the hospital, what is relevant is the time that passed after the scheduled time in which they have not yet been attended.

Thus, another opportunity for improvement would be for the information system to provide not only a staggering appointment schedule but also the possibility of scheduling according to patient characteristics, such as age, severity of the case, type of outpatient clinic, or place of origin.

Finally, after obtaining key performance indicators (KPIs) related to time and to patient and outpatient characteristics, Alpha Hospital can propose and study the possibility of the "TO-BE" models that could make patient care more efficient.

It was not possible to involve all process professionals, taking into account the temporal limitations of this study and the availability of Alpha Hospital stakeholders. Even though practically all management professionals have been involved, there is a probability, although reduced, of any professional having a different perception of the process or that some relevant aspect has not been identified. It was also not possible to contact patients directly for legal reasons. The patient's perspective of the process would have been important, especially to validate (a) whether the perception of the problems identified in the study also corresponds to the problems actually felt by the patients and (b) whether the improvements identified can respond to patients' wishes for an improved process and care. Being aware of these limitations, the research team sought to minimize these aspects by observing the process in loco and during the interviews and by presenting the intermediate and final results.

BPMN modeling has other limiting aspects because it focus on the existing activities and how they are performed. There are several process improvement opportunities related to other aspects of the process, such as communication within the organization, lack of strategic alignment, relevant runtime measurement points for the activities and the process as a whole, information availability to manage the end-to-end process, and mainly how the patient would like

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to interact with this process. In this specific case study, the identification of opportunities related to the presented aspects were limited.

6 | CONCLUSIONS AND FUTURE WORK

The article presents a case study carried out at a tertiary-level hospital specializing in pediatrics (Alpha Hospital) with the objective of identifying the opportunities for improvement in outpatient care of the patient through the modeling of the process using BPMN. The AS-IS process was modeled, which allowed the organization to have a visualization and understanding of the process operation and the main aspects of improvement to be achieved. It can be affirmed that there is a good general perception of the steps to be taken in outpatient care but the employees themselves still have doubts about what a process really is and where its beginning, middle, and end are.

Improvements have been identified, including (a) scheduling of consultations based on characteristics of the patients being treated, for example, their home location, instead of all appointments of 1 day being scheduled at the same specific hour; (b) using a sociotechnical approach; (c) introduction of a continuous improvement process with the definition of KPIs and regular review procedures. There is also extensive work to be carried out beyond the identification of the appropriate KPIs, such as understanding the adequacy of the information systems in order to obtain the data that allow the calculation of these indicators at various levels, such as the process execution cycle (process instance) level, each task execution level, and finally the process as a whole. In conjunction with this work, there should be a simultaneous effort to sensitize stakeholders to the need to make evidence-based decisions as indicated by KPIs. Designing and implementing a roadmap for implementing KPIs is another possible future research work.

Regarding the limitations of the work, the modeling and its impressions through the interviews focused on medical care and the peculiarities of a teaching hospital and do not take into account other technical or operational factors. In this context, another future research topic will be to analyze other cases in which several techniques of characterization and analysis of processes can be combined by verifying the opportunities for improvement and seeking the generalization of their results. We also have as a future work to adjust the process to include multidisciplinary patient care, adding activities performed by psychologists, nutritionists, physiotherapists, among other health professionals, and to cover the patient's perspective on the process vision and suggestions for improvement.

Taking into account that this is a case study, the use of the results in other realities has to be carried out in a prudent manner. The modeling performed may, however, represent an element of comparison with other realities and serve as a starting point for a discussion to be held in another hospital. The proposed improvements resulting from the modeling also have to be considered in the restricted scope of this study, although it may also serve as an element of reflection for other research carried out in other hospitals.

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REFERENCES

Aguilar, E. R., García, F., Ruiz, F., Piattini, M., Calahorra, L., García, M., & Martin, R. (2008). Process modeling of the health sector using BPMN: A case study. In *Proceedings of the First International Conference on Health Informatics*, *HEALTHINF 2008*, Funchal, Madeira, Portugal. 173–178.

Ajmi, I., Zgaya, H., Gammoudi, L., Hammadi, S., Martinot, A., Beuscart, R., & Renard, J. M. (2015). Mapping patient path in the Pediatric Emergency Department: A workflow model driven approach. *Journal of Biomedical Informatics*, Elsevier Inc., *54*, 315–328. https://doi.org/10.1016/j.jbi.2014.12.004

Amin, M., & Nasharuddin, S. Z. (2013). Hospital service quality and its effects on patient satisfaction and behavioural intention. *Clinical Governance: An International Journal*, *18*(3), 238–254. https://doi.org/10.1108/CGIJ-05-2012-0016

Askari, M., Westerhof, R., Eslami, S., Medlock, S., de Rooij, S. E., & Abu-Hanna, A. (2013). A combined disease management and process modeling approach for assessing and improving care processes: A fall management case-study. *International Journal of Medical Informatics*, *82*(10), 1022–1033. https://doi.org/10.1016/j.ijmedinf.2013.06.011

Association of Business Process Management Professionals (ABPMP) (2013). Guide to the business process management common body of knowledge – BPM CBOK Version 3.0. CreateSpace Independent Publishing Platform, Version 3.0, 3th edition. http://www.abpmp.org

Berg, M. (1999). Patient care information systems and health care work: a sociotechnical approach. *International journal of medical informatics*, *55*(2), 87–101. https://doi.org/10.1016/S1386-5056(99)00011-8

Bisogno, S., Calabrese, A., Gastaldi, M., & Levialdi Ghiron, N. (2016). Combining modelling and simulation approaches: How to measure performance of business processes. *Business Process Management Journal*, *22*(1), 56–74. https://doi.org/10.1108/BPMJ-02-2015-0021

Cape, J. (2002). Consultation length, patient-estimated consultation length, and satisfaction with the consultation. *The British Journal of General Practice*, *52*(485), 1004–1006. http://www.ncbi.nlm.nih.gov/pubmed/12528588

da Silva, L. A., Damian, I. P. M., & de Pádua, S. I. D. (2012). Process management tasks and barriers: Functional to processes approach. *Business Process Management Journal*, *18*(5), 762–776. https://doi.org/10.1108/14637151211270144

Doosty, F., Yarmohammadian, M., & Ebrahimipour, H. (2014). Improvement of hospital processes through business process management in Qaem Teaching Hospital: A work in progress. *Journal of Education and Health Promotion*, Medknow Publications, *3*, 111. http://www.ncbi.nlm.nih.gov/pubmed/25540784

Dufresne, T., & Martin, J. (2003). Process modeling for e-business, INF 770 – Methods for Informations Systems Engineering: *Knowledge Management and E-Business*, George Mason University, Fairfax, VA. 1-28.

Feagin, J. R., Orum, A. M., & Sjoberg, G. (Eds.) (1991). *A case for the case study*. Chapel Hill, NC: University of North Carolina Press. 300 p

Graeber, S. (1997). The impact of workflow management systems on the design of hospital information systems. In *AMIA Symposium*.

Harrison-Broninski, K. (2010). Dealing with Human-Driven Processes. In J. vom Brocke, & M. Rosemann (Eds.), *Handbook on business process management 2* (pp. 441–460p). Berlin, Heidelberg: Springer Berlin Heidelberg. http://link.springer.com/10.1007/978-3-642-01982-1

Jeston, J., & Nelis, J. (2006). *Business process management: Practical guidelines to successful implementations*. Oxford: Elsevier. 437 p

Ko, J., Gao, T., Rothman, R., & Terzis, A. (2010). Wireless sensing systems in clinical environments: Improving the efficiency of the patient monitoring process. *IEEE Engineering in Medicine and Biology Magazine.*, *29*(2), 103–109.

Lakshmi, C., & Appa Iyer, S. (2013). Application of queueing theory in health care: A literature review. *Operations Research for Health Care*, *2*(1–2), 25–39. http://linkinghub.elsevier.com/retrieve/pii/S2211692313000039

10991441, 2018, 3, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/hpm.1571 by Instituto Politecnico De Leiria, Wiley Online Library on [15/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Lenz, R., & Reichert, M. (2007). IT support for healthcare processes – premises, challenges, perspectives. *Data & Knowledge Engineering*, *61*(1), 39–58. https://doi.org/10.1016/j.datak.2006.04.007

Maddern, H., Smart, P. A., Maull, R. S., & Childe, S. (2013). End-to-end process management: Implications for theory and practice. *Prod Plan & Control*, *25*(16), 1303–1321. https://doi.org/10.1080/09537287.2013.832821

Manfreda, A., Kovacic, A., Štemberger, M. I., & Trkman, P. (2014). Absorptive capacity as a precondition for business process improvement. *The Journal of Computer Information Systems*, *54*(2), 35–43. https://doi.org/10.1080/08874417.2014.11645684

Martinho, R., Rijo, R., & Nunes, A. (2015). Complexity analysis of a business process automation: Case study on a healthcare organization. *Procedia Computer Science*, *64*, 1226–1231. https://doi.org/10.1016/j.procs.2015.08.510

Object Management Group (OMG) (2011). Business Process Model and Notation (BPMN) version 2.0. http://www.bpmn.org

Onggo, B. S. S. (2014). Agent-based simulation model representation using BPMN. In *Formal languages for computer simulation: Transdisciplinary models and applications* (pp. 378–399). IGI Global.378–400. https://doi.org/10.4018/978-1-4666-4369-7.ch012

Paim, R., Caulliraux, H. M., & Cardoso, R. (2008). Process management tasks: A conceptual and practical view. *Business Process Management Journal*, *14*(5), 694–723. https://doi.org/10.1108/14637150810903066

Penteado, A. P., Molina Cohrs, F., Diniz Hummel, A., Erbs, J., Maciel, R. F., Feijó Ortolani, C. L., … Torres Pisa, I. (2015). Kidney transplantation process in Brazil represented in business process modeling notation. *Transplantation Proceedings*, *47*(4), 963–966. https://doi.org/10.1016/j.transproceed.2015.03.044

Pereira, L. M. V., Tonani, M., Somera, S. C., da Costa, J. M. H., & de Pádua, S. I. D. (2016). Application of modeling in a drug distribution and dispensing process focused on traceability in a surgical center. *Knowledge and Process Management*, *23*(2), 161–168. http://doi.wiley.com/10.1002/kpm.1514

Rebuge, Á., & Ferreira, D. R. (2012). Business process analysis in healthcare environments: A methodology based on process mining. *Information Systems*, *37*(2), 99–116. http://linkinghub.elsevier.com/retrieve/pii/S0306437911000044

Simons, H. (2009). *Case study research in practice*. London: SAGE. 189 p.

van der Aalst, W. M. P. (2004). Business process management demystified: A tutorial on models, systems and standards for workflow management. *Lectures on Concurrency and Petri Nets*, *3098*, 1–65. https://doi.org/10.1007/978-3-540-27755-2_1

van der Aalst, W. M. P. (2013). Business process management: A comprehensive survey. *ISRN Software Engineering*, *2013*, 1–37. https://doi.org/10.1155/2013/507984

Weske, M. (2007). *Business process management: Concepts, languages, architectures*. Berlin: Springer-Verlag Berlin Heidelberg. 332p. https://doi.org/10.1007/978-3-540-73522-9

Yin, R. K. (1994). *Case study research: Design and methods* (2th ed.). Thousand Oaks, CA: Sage Publications. 170 p.

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