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SYSTEMS-LEVEL QUALITY IMPROVEMENT

The Impact of Perioperative Data Science in Hospital Knowledge Management

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Abstract

Conservative practices, such as manual registry have limited scope regarding preoperative, intraoperative and post-operative decision making, knowledge discovery, analytical techniques and knowledge integration into patient care. To maximize quality and value, perioperative care is changing through new technological developments. In this context, knowledge management practices will enable future transformation and enhancements in healthcare services. By performing a data science and knowledge management research in the perioperative department at Hospital Dr. Nélio Mendonça between 2013 and 2015, this paper describes its principal results. This study showed perioperative decision-making improvement by integrating data science tools on the perioperative electronic system (PES). Before the PES implementation only 1,2% of the nurses registered the preoperative visit and after 87,6% registered it. Regarding the patient features it was possible to assess anxiety and pain levels. A future conceptual model for perioperative decision support systems grounded on data science should be considered as a knowledge management tool.

Keywords Perioperative data science · Knowledge management · Clinical decision support systems · Hospital information systems

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Introduction

Context

Population aging is an unquestionable reality and a growing phenomenon pointing to a large increase in the elderly population. In 2013 life expectancy was 80 years. Old population in the United States will result in a significant increase of surgical services and in Portugal the trend will be identical. On the other hand, most health systems collect at least some individual patient data during clinical face-to-face encounters. While the conventional way to collect such data are on paper forms and register books, increasingly, face-to-face encounters are being captured electronically. Electronic health systems have the potential to change the health care system from a mostly paper-based production to one that utilizes clinical and other pieces of information to assist care providers in delivering more quality to their patients [1]. Keeping these data personalized rather than anonymous is facilitated by using electronic records and hospital information systems which can more easily store, access, analyse, and share data. This trend will continue as improvements are made in computer hardware, software, and telecommunication infrastructure and as countries develop the skills necessary to implement electronic data storage and transmission systems [2].

Motivation and rationale

Perioperative care is emerging rapidly as technology advances and increases complexity to maximize quality, healthcare value, patient and professional security. While innovations in diagnostic and therapeutic technologies have driven past improvements in quality of perioperative care, future transformation in care will be enabled by data [3].

The perioperative background is a unique environment that includes many challenging variables: complex clinical care performed by teams, high cost, sophisticated technologies that often do not interoperate and a large array of supplies, instruments, and implants that are difficult to manage. These variables create a setting of massive complexity and are a source of a significant percentage of patient safety-related adverse events [4].

Conventional methodologies, such as registry studies, are limited in their scope for discovery and research, extent and complexity of data, breadth of analytic techniques, and translation or integration of research findings into patient care [3].

Objectives

The purpose of this research project was to assess the impact of integrated perioperative data science tools in hospital knowledge management. The main objectives were:

- Design, construct and implement a Perioperative Electronic System at Doctor Nélio Mendonça Hospital;
- Define a research approach and conceptual model for perioperative decision support systems grounded on data science and knowledge management (KM);
- Assess new patient features and create new clinical knowledge for healthcare decision making before and after the Perioperative Electronic System implementation;
- Produce perioperative nursing production and quality indicators.

Contributions

This study is a relevant step for perioperative care towards a perioperative decision support system (PDSS). The theoretical background is based on a conceptual model using data science and knowledge management practices. This framework intends to deal with the complexity and scope of the current perioperative demands, such as infections and adverse events reduction, information added to inform healthcare professionals, decisions, guidelines, best practices, policy, costs and training, thereby improving the safety and quality of healthcare and its value.

Background and literature review

Perioperative electronic system as a hospital information system

Modern hospital information systems (HIS) are comprehensive, integrated and specialized information systems designed to manage the administrative, financial and clinical aspects of hospitals and healthcare facilities. They are considered one of the most important focal points on which the delivery of healthcare within hospitals and different types of medical institutions depends [5]. Despite evidence of these benefits, physicians' and hospitals' utilization of HIS and electronic health records are still low [5].

Perioperative procedures and its different stages are often the most intensive and efficacious therapeutic interventions available in medicine and these treatments are frequently curative and are sometimes the only alternative for patients. Surgeons and other professionals are highly trained thus the technology and resources that they employ are typically advanced, expensive and scarce. So, the optimization of these limited resources is paramount to the safe, effective, and efficient delivery of healthcare [6].

Perioperative information technology has the potential to improve the quality of health care, reduce costs, decrease medication administration errors, reduce time spent on paperwork,

increase management efficacy and allow affordable access to health care.

According to Fig. 1 it should render all the preoperative stages and process. Researchers concluded that IT or automation of aspects of the surgical patient preparation process and the coordination and management of surgical equipment has the potential to increase the speed of information exchange, reduce interruptions to clinicians and decrease the possibility of adverse events in the perioperative setting. With migration to the use of an electronic health record in the operating room (OR), time that nurses previously spent on paperwork and administrative functions can be dedicated to providing better patient care and ensuring accuracy in documentation [7, 13].

Data science in healthcare

The emergence of perioperative data science is a key element to addressing limitations and creating a sustainable path toward evidence-based improvement for interventional healthcare. Perioperative data science process is to create tools to measure, model and quantify the pathways or processes within the context of patient health states or outcomes, and use information gained to inform healthcare decisions. Data is pervasive throughout the surgical care pathway; thus, data science can impact various aspects of care including prevention, diagnosis, intervention, or post-operative recovery. A data science approach to surgical decision-making could more accurately predict severe complications using complex data from pre-, intra-, and post-operative contexts, how it could support intraoperative decision-making using both existing knowledge and continuous data streams throughout the surgical care pathway, and how it could enable effective collaboration between human care providers and intelligent technologies [3].

The confluence of science, technology, and medicine in our dynamic digital era has spawned new data applications to develop prescriptive analytics, to improve healthcare personalization and precision medicine, and to automate the reporting of health data for clinical decisions.

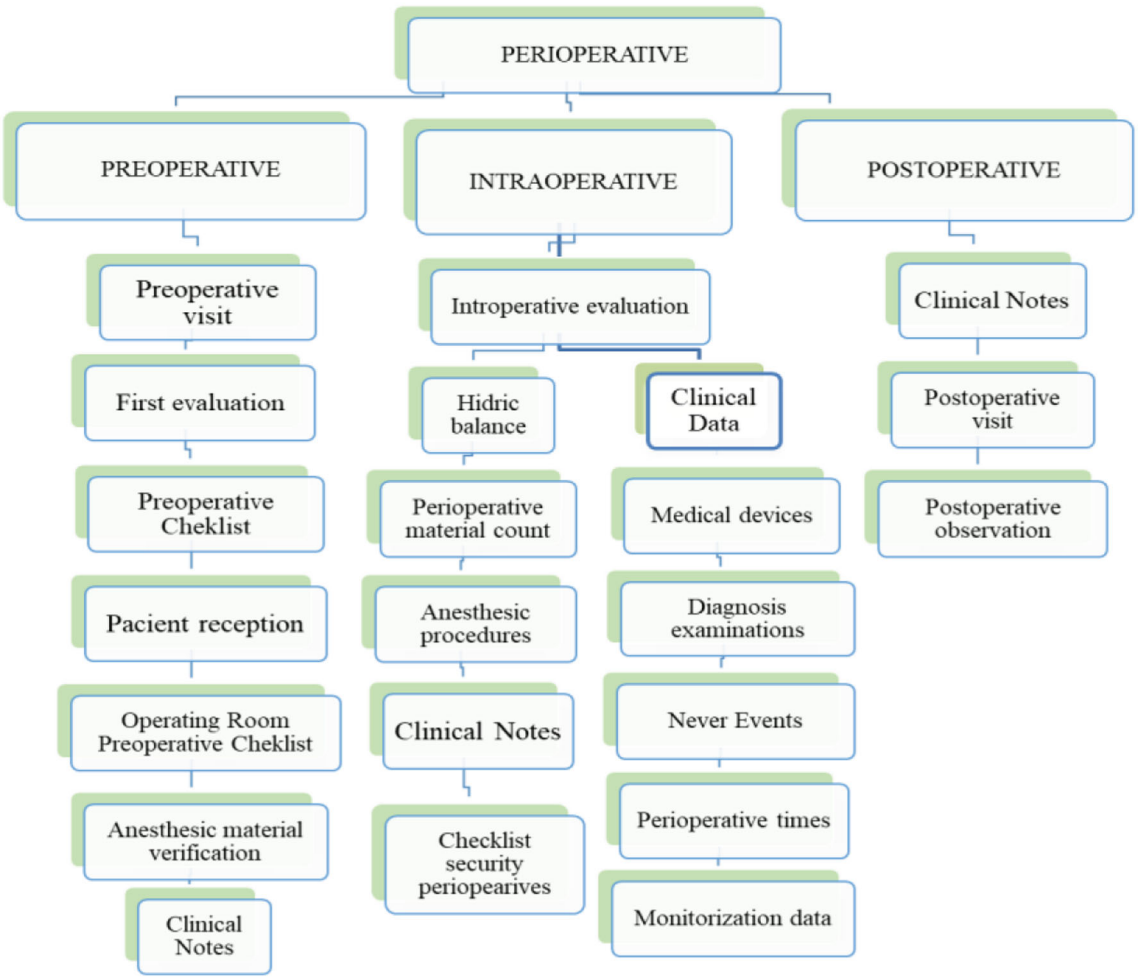

Fig. 1 Perioperative electronic system (overview)

Data science in health care has seen recent and rapid progress along 3 paths: (1st) through big data via the aggregation of large and complex data sets including electronic medical records, social media, genomic databases, and digitized physiological data from wireless mobile health devices; (2nd) through new open-access initiatives that seek to leverage the availability of clinical trial, research, and citizen science data sources for data sharing; and (3rd) in analytic techniques particularly for big data, including machine learning and artificial intelligence that may enhance the analyses of both structured and unstructured data [8].

Knowledge management in healthcare

Information and knowledge are key organizational resources used to define appropriate strategies and business plans that should translate reality accurately. Knowledge is organized and analysed information in order to make it understandable to apply to problem resolution and decision making [9].

Value creation is only achieved through knowledge creation, its disseminating throughout the organization, developing and expanding new products and services. On the other hand, the competitive success is reflected by the way intellectual capital is managed, since its capture, encoding and transfer to obtain new skills through training and business process reengineering. Knowledge management also allows individuals to make informed and effective decisions [10].

In service base companies, knowledge is a central intangible asset where knowledge management deals with the creation, use, reuse, dissemination of Knowledge. The growing role of information technologies enabled the development of efficient KM tools using databases and collaborative software [11].

Knowledge management (KM) is a recognised field with many applications and techniques and its implementation in health care is challenging. Health care can profit from many advantages that KM can provide but numerous challenges are current, some are proper to KM and other particular to the health care ground [11].

Health care delivery relies heavily on knowledge and evidence-based medicine and the delivery of care replies on cooperation of several partners that need to exchange their knowledge in order to provide care with quality and efficiency. In health care, KM is being developed mainly in the domain of electronic health record management and health organization management; in this context, previous researches in the business domain have been adapted and applied to the Healthcare Knowledge Management [11].

A strong technological infrastructure, customized for the needs of each organization, provides the tools necessary for ensuring the success of knowledge management efforts. What emerges from the countless of corporate experiences is that KM does not require more or better tools to gather more data and information but rather does require a new perspective to link the pieces of information that promotes understanding and accelerates action - in other words, to create knowledge [12].

The methods and techniques in KM can be categorized in three groups: people and technology, requirements elicitation and value measurement. Regarding the Technical Perspective, KM tools deals with explicit knowledge, meaning that Knowledge can be written on a support that is mainly an electronic one. Several concepts from the broad computer science research, such as data mining, rules based reasoning, and multi-agent systems have been integrated in KM solutions, the integration of those tools depends on the processes in action [11].

Knowledge management practices need more effective results for the healthcare learning organization. Data science techniques can be used to automate knowledge extraction and representation, helping KM program leaders to get closer to that elusive goal (*see* Fig. 2).

Research methodology

Sample and setting

The setting for this project was the operating room at Dr. Nélio Mendonça Hospital between 2013 and 2015 (Funchal, Madeira Island, Portugal).

Perioperative nurses and patients were the targeted populations for this project and were divided in two groups and stages: before and after the implementation of the electronic system.

This sample population was non-probabilistic and causal as a matter of convenience. The 113 nurses were divided in two groups: the 1st group had 83 nurses and 2nd had 30 nurses. These nurses came from all areas of perioperative services. Inclusion criteria for the sample included the following: must be a perioperative registered nurse.

There was a second sample of 460 surgery patients also divided in two groups with 230 patients in each one. Inclusion criteria for this sample included patients with 65 years old and more for elective surgery with no signs of cognitive deficit.

Type of study

An observational, quantitative and descriptive survey design was used to determine perioperative nursing registry practices towards the use of the electronic system in providing.

Regarding the surgery patients, a correlational and longitudinal study design was performed to evaluate new assessed features.

Fig. 2 Knowledge creation process using data science and KM tools

Data collection

An observation grid was prepared for the perioperative nurses in the intraoperative, postoperative and preoperative stages. For perioperative patients, a questionnaire was created to demographic and clinical data, Amsterdam Preoperative Anxiety and Information Scale (APAIS), Spielberger State-Trait Anxiety Inventory (STAI), postoperative pain, pressure ulcers, Barthel scale and falling risk were features also measured.

Preparedness planning

Electronic perioperative system creation and implementation

First of all, for the Electronic Perioperative System conception and implementation a task force was gathered, including surgeons, anesthesiologists, nurses and computer engineers.

The main stages included:

- Presentation of the Perioperative Electronic System to surgeons, anaesthetists, perioperative nurses and others involved in the surgical process;
- Clarification of its implementation;
- Explanation of the advantages of improving assistance care, with greater security to the surgical process, not only for the patient, but also for health professionals and units;
- Alert to the importance of this system as a knowledge management tool, innovating and developing the perioperative process by gathering production, structure, process and outcome indicators.

A literature review on perioperative nursing was performed with special consideration for external/internal norms, guidelines and mandatory protocols inherent to the operating room and perioperative nursing records from imperative organizations like *Direção Geral da Saúde* (DGS) (Portuguese administrative healthcare) and Dr. Nélio Mendonça Hospital to assure its effective execution.

The intervention strategies established periodic meetings with the different intervening areas; training session's development for surgical services nurses in the operating room and in the "Perioperative Nursing" situation; monitoring and evaluating perioperative electronic system procedures; continued adjustment and development and confidentiality concerning the use of clinical data.

Perioperative nurses observation

This system was designed with a specific layout for the surgical procedure which gathers three main stages: intraoperative, postoperative and preoperative processes. This system implementation led all health professionals like surgeons, anaesthesiologists, nurses and other technicians to work in an organized manner and in one platform, with more detailed, standard, completed and updated procedures. These procedures followed DGS guidelines and policies. New data was registered like surgical procedure duration that was not accounted for surgical safety checklist. A new direct connection to national databases, participation in HELICS - Hospitals in Europe Link for Infection Control through Surveillance and updated waiting lists were promising.

In the preoperative stage a preoperative visit was conducted and applied a preoperative checklist (service and block) observing the patient reception at the OR and recorded registration.

In the intraoperative stage the action plan continuity, nursing diagnoses and record registration were observed.

In the postoperative stage the post anaesthetic care, postoperative visit and record registration were observed.

Statistical methods

The statistical methods used descriptive measures, T-Student test for independent samples and One-way Anova. The statistical package was IBM SPSS 22.0 and the significance level $\alpha = 0,05$.

Principal results

Perioperative patients

Perioperative patients assessed in both groups were mostly women (1st group: 57,8%/ 2nd group: 63%) between 65 and 69 years old (1st group: 36,5%/ 2nd group: 30%). Performed surgeries were manly major (1st group: 70%/ 2nd group: 78,7%) with general anaesthetic (1st group: 58,7%/ 2nd group: 59,1%). The medium surgery time was 2 h and 58 min in the first group. In the second group it was 3 h and 2 min.

Patient features assessed were anxiety and pain levels, falling risk exhibited that after the implementation of the perioperative electronic system the anxiety levels (1st group: 13,72/ 2nd group: 10,97) monitored and the falling risk (1st group: 57,0%/ 2nd group: 48,3%) were lower than before (p value <0,05). The pain level observed in the preoperative stage (1st group: 2,66/ 2nd group: 1,19), intraoperative stage (1st group: 2,05/ 2nd group: 0,72) and postoperative stage (1st group: 4,5/ 2nd group: 0,45) was also inferior after the implementation of the perioperative electronic system (p value <0,05).

Perioperative nurses

The nursing plan was registered by 62,7% nurses; there was no register about the security checklist and time indicators like the operative times. After the electronic system implementation, the nursing plan was registered by 96,7% of the nurses, security checklist and operative times was recorded by 100%. In the postoperative stage, before the perioperative electronic system implementation in the OR the acute pain monitoring was not registered, and the register of the postoperative visit was recorded by only 4,8% of the nurses. After the electronic system implementation, the acute pain monitoring and the postoperative visit was registered by 86,7% of the nurses. The new registry in the perioperative period included recorded operative times, which were not counted in the patients, surgical safety checklist application, with direct linkage to the national database for epidemiological surveillance of surgical site infection HELICS-Surgical Site Infection and updated waiting lists.

Regarding professionals, before the perioperative electronic system implementation in the OR, only 1,2% of the nurses registered the preoperative visit and after its implementation 87,6% of the nurses registered it.

Discussion

This research project aims to contribute in the fields of data science and knowledge management for healthcare systems, and more specifically, for perioperative (and clinical) decision support systems.

The purpose of this research project was to assess the impact of integrated perioperative data science tools in hospital knowledge management. According to the literature review, electronic health records utilization is still low despite evidence of HIS benefits [5]. By implementing a perioperative electronic system at Dr. Nélio Mendonça Hospital operating room the records in paper form were now computerized. Perioperative nursing practices which included preoperative visit data, intraoperative interventions and postoperative visit were performed with higher data registry after implementing the perioperative electronic system. Regarding the surgical patient, postoperative acute pain and anxiety levels were also monitored showing lower levels after this system implementation.

The migration to the electronic health records in the operating room (OR), time that nurses previously spent on paperwork and administrative functions were dedicated to providing better patient care and ensuring accuracy in documentation [7]. With the reorganization and compilation of these components and instruments in the OR, professionals cooperated by resolving many problems, never discussed before, and that, in a way, converged for the quality assurance and safety of perioperative care conditions, for all the intervenient.

Technology that is designed expressly for and adequately tailored to the demands of the perioperative care process and requirements resulted in optimal clinical adoption and outcomes. By assessing health gains through the application of a dynamic and holistic model created for surgery patient features and perioperative nursing practices the results indicate that the perioperative electronic system was beneficial to the nurses and to the surgery patients.

Conclusions and final recommendations

Nowadays challenges in perioperative and surgical care are overwhelming. Perioperative care is complex and involves multiple interconnected subsystems which are a microcosm of the hospital. Surgical procedures are major drivers of patient morbidity, mortality, satisfaction, and overall hospital costs and profitability. To fulfill the promise of new informatics and technology approaches, a dramatic change is needed in

how technology is designed, deployed, and supported within the perioperative environment.

At Dr. Nélio Mendonça Hospital the implementation of this perioperative electronic system was a major step and faced some challenges. In order to evolve to the next stage of its development it is vital to assess the acceptance and satisfaction among the end users and assess the maturity's system [14].

Compliance with Ethical Standards

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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