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The Benefits of Electronic Health Record (EHR) on Operating Room Efficiency: Literature Review

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Abstract
Background: The Electronic Health Record (EHR) system is a systematic collection of health information based on electronics and integrated with information systems in the hospital network. The use of the EHR system is very important in a comprehensive strategy to improve the quality of health and patient safety, especially in the operating room.
Purpose: to find out the benefits of using EHR on operating room efficiency which includes treatment costs, OR efficiency metrics, turn over time, documentation time and nursing quality.
Method: This literature review was searched through relevant evidence-based studies usingdatabase at PROQUEST, Science Direct, Scopus, Elsevier from 2017-2021.
Results: The EHR system has a cost-saving impact on the average operating room cost of 36-37 dollars per minute and can reduce costs during pre, intra and post surgery. For the FPIR value from the data of 27,403 cases after post-implementation to 9,630 cases, it means that there are no missing patients to enter the operating room, while at the time of delay the FCOTSin pre-implementation of EHR was 1972 cases or (7.20%) and post-implementation 377 cases (3.91%). Meanwhile, the turn over time (TOT) after post implementation showed a significant increase of 53 minutes, $p < 0.001$. The introduction of the EHR also had an impact on increasing documentation time for nurses from 23% to 35%. In addition, it also provides benefits to the quantity and quality of nursing.
Conclusion: The usefulness of the EHR system contributes to increasing the efficiency of the operating room so that it can provide effectiveness in service and quality of care. Nurses are expected to be able to input the EHR system and service agencies can implement these technological developments.

Keywords: EHR, operating room efficiency, turnover time, documentation, nursing quality

Introduction

The operating room is the most important financial center in a hospital and is an interaction for patients in the health system and has a major impact on the hospital's financial solvency. With more than 48 million outpatient procedures and 51 million inpatient procedures performed, surgical care accounts for approximately one-third of all healthcare expenditures.[1,2] It was reported that operating room costs (OR) increased from 7 dollars to 100 dollars per minute.[3] In addition, from 40% of hospital costs, operating rooms provide 60-70% of income.[4] With such significant income, we all have a strong vested interest in maximizing operating room efficiency. In increasing the efficiency of the operating room, it is necessary to pay attention to improving patient safety and quality of service. Operating room management is complex and dynamic, requiring processes and planning to account for changes that often occur on the day of operation.[5] Moreover, keeping the operating room functioning at optimum efficiency is no easy task to maximize the total number of surgeries per day and to ensure patient safety.

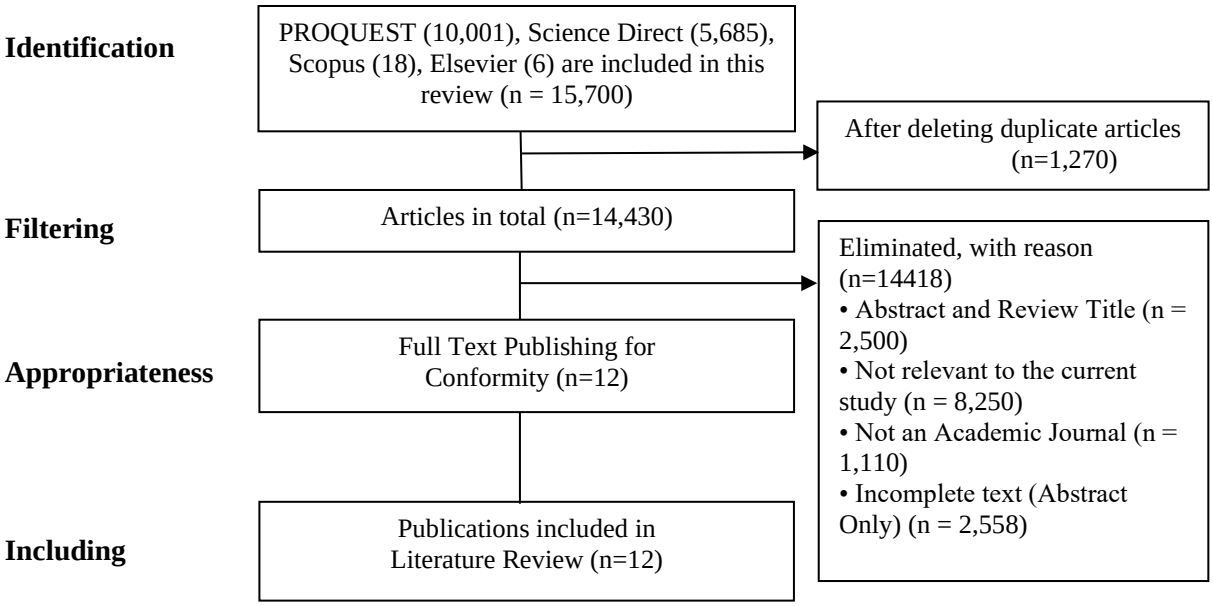
Much of the complexity of operating theaters stems from uncertainty, where unexpected patient factors such as preoperative instructions, timeliness of surgery, length of fasting period, or medical clearance can lead to last-minute cancellations.[4] In addition, surgeon factors can also cause delays; this was due to conflicting tasks and poor communication between staff about equipment requirements and other surgical preparations. This also applies to the factor of the anesthesiologist who is responsible for monitoring the operating room system and induction time. In addition, system factors can also cause delays such as loss of documents, inability to find preoperative laboratory results, loss of equipment, and staff changes for meals or breaks.[6] In response to the challenges and problems mentioned above, several innovations can improve patient safety and improve outcomes in surgical treatment, especially in increasing operating room efficiency. Hospitals should focus on increasing efficiency to meet the increasing demand for providing high quality and cost-effective care.[7] Some experts consider that information technology is the key and one of the strategies to increase effectiveness, efficiency, and quality in health services. The Electronic Health Record (EHR) system has been widely used in New South Wales for more than a decade and also the EHR aims to assist doctors and quality health care to patients and maintain their safety.[1,3,8]

The benefits of EHR systems have also been noted domestically, with one study noting that greater access to information improves clinical decision making and reduces errors. With the increasing adoption of electronic health records (EHRs), a mobile application has been developed that can provide voice to electronics for security and replace paper-based information transitions.[9,10] The difficulty in drawing conclusions regarding the benefits of EHR is due to several factors, including the broad spectrum of commercially available EHR systems, the mixed taxonomy used by various studies, intrinsic site and utilization differences, and the absence of standardized measures in the assessment of EHR performance.[3,11] Therefore, the purpose of this paper is to determine the benefits of EHR on operating room efficiency which includes operating room maintenance costs, operating room efficiency metrics, changeover time, documentation time, and nursing quality. The purpose of writing this manuscript is to determine the benefits of Electronic Health Record on operating room efficiency.

Method

The method used is a literature review by looking for literature through relevant evidence-based studies is with the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) flow. The database used is PROQUEST, Science Direct, Elsevier, with several keywords such as EHR, operating room efficiency, turn over time, documentation, and nursing quality. Journals were selected based on the relevance of journal content to the purpose of writing this literature study. In the process of preparing the journal, several inclusion criteria were taken, namely: 1) full text, 2) in English, 3) clearly explaining the objectives and research methods, 4) having a relationship with the benefits of EHR on efficiency in the operating room, 5) published in the period 2017-2021. Exclusion criteria included: 1) abstract and title of the review only, 2) not related to the scope of the EHR.

Chart 1. Literature Selection Process with PRISMA Method



Results

According to the Canadian Pediatric Center in 2007 (David H. Rothstein, et al., 2018), there are several operating room efficiency metrics such as; (1) Procedure cancellation rate was defined as same-day cancellation including unexpected cancellations or delays, (2) First surgery start time (FPIR), (3) Measuring operating room and patient readiness (FCOTS) where two commonly used metrics are: first patient in the room (FPIR), (4) Operating room utilization, (5) Percentage of unplanned closures including unexpected equipment, staff or equipment breakdowns, (6) Accuracy of case duration, (7) Accurately allocating staff scheduling to predict the time required for each procedure for each surgeon. In addition, documentation time and nursing quality are supporters in increasing operating room efficiency.[6]

Treatment Costs

Understanding the cost of surgical care is critical to value-based care. Costs for hospital stays with surgical procedures amounted to 187.1 billion in 2014, accounting for 48% of all hospital costs. Operating room costs are the second most expensive part of surgical treatment. Previous studies estimated the actual cost per unit time to run the operating room. This explains some of the large variation in the reported estimation of operating room time from 30 dollars to over 100 dollars per minute.[12]

Operating Room Efficiency Metrics

In the examination, two commonly used metrics, the name first patient in the room (FPIR) on time and first case on time started (FCOTS) are operating room efficiency metrics. The high rate of on-time FPIR and FCOTS is the excellence of an operating room that is efficiently run, and from that result, we hypothesized that EHR had an impact on these outcomes.[12,13] During the study timeline, there were 111,437 scheduled operations to be scheduled. Of these, 37,319 were the first cases or FPIR after deletion of cases from the type of surgical service. Cases that counted FPIR and FCOTS delays greater than 180 minutes were then visually examined and determined for data inclusion. In the post-implementation group, there were 9,630 cases. This means that there is no missing value for "patient into the room", allowing calculation of the FPIR delay for all cases. The FCOT value in the pre-implementation of EHR was 1972 cases or (7.20%) and 377 cases post-implementation (3.91%). This corresponds to an Odds Ratio of 0.6963 (CI 0.4728–0.9992, p= 0.0495) for missing data in the post as

opposed to the pre-implementation period. This study has shown a significant relationship between the implementation of the EHR system on the FCOTS and FPIR metrics, where both of which are very important measures in measuring operating room efficiency.[13]

Turnover time

This study was conducted to evaluate the effect of implementing a new EHR system in the operating room as well as the efficiency and turnover time (TOT) of surgical cases in our institution. The data on the TOT were collected after implementing the EHR (Epic) from June 2015 to May 2016, which replaced the transition from paper and electronic records. The cases were divided into pre-and post-implementation groups for comparison. In the pre-implementation group, 13,297 cases were found during the study period. In the post-implementation group, 12,202 results were obtained. Overall, there was a significant increase in the average post-implementation of TOT compared to pre-implementation. The largest increase was seen in the first month (63.0 vs. 53.0 min, $p < 0.001$), which did not subside in the second month (59.9 vs. 53.0 min, $p < 0.001$). In this study, we show a significant relationship between the transition from one EHR system to another EHR system and decreased TOT impact or efficiency.[11]

Documentation Time

Nine studies reported correlation time with the presence of an EHR system for patient medical records, seventeen with a paper-based documentation system, and two documentations examined the time before and after EHR implementation. The sample size in the included studies ranged from 7 to 114 hospital staff was observed. There were considerable variations in the reported percentages of time spent on documentation tasks, ranging from 4% for pre-EHR nurses to 39% for post-EHR doctors. One-time documentation was checked at baseline and 6 months after the introduction of the EHR. The authors found a 9% increase in the documentation for physicians (from 30% to 39%) and a 2% increase for nurses (from 25% to 27%) six months after the implementation of the EHR system. Another comparison created by observing the documentation time at baseline with 12 months after the introduction of the EHR was 12%, and an increase in documentation time for nurses was found (from 23% to 35%).[14]

Nursing Quality

Nurses are expected to be the largest users of Electronic Health Records (EHR) in hospitals. Nursing professionals make up the largest proportion of the health workforce.[6] so they are the highest EHR users in hospitals. Nursing care directly affects the outcome of patient care in hospitals. Since the 1990s, a large number of indicators have been used to create health and patient quality standards benchmark. Improvements in clinical practice in nursing care delivery across settings and jurisdictions. Studies reporting the impact of implementing an EHR system on nursing documentation are inconsistent. Data on the quantity, quality, and timeliness of nursing documentation, were identified as important in professional standards.[6]

Table 1. The results are described and illustrated in the following breakdown table

No	Author	Method	Setting	Objective	Finding
1	Baumann, L. et al,.(2018)	Systematic review	Australia	To review compares time spent on documentation tasks by hospital staff (physicians, nurses, and interns) before and after EHR implementation.	The initial adjustment to EHR appears to increase documentation time but there is some evidence that as staff become more familiar with the system, it may ultimately improve workflow

2	Joseph McDowell et al,.(2017)	Case Study	New York	to evaluate the effect of deploying a new EHR system on operating room efficiency and surgical case turnover time (TOT) at our institution	EHRs have the potential to improve hospital workflow, caution is advised in the case of operating room implementation.
3	Albert Y. Huang, et al,.(2017)	Study design	New York	This study developed an inexpensive, automated OR utilization system and analyzed data from multiple operating rooms	The SmartOR automatically and reliably captures data on OR room state and, in real-time, identifies outlier cases that may be examined closer to improve efficiency. As no manual entry is required, the data are indisputable and allow OR teams to maintain a patient-centric focus
4	David H. Rothstein, et al,.(2018)	Systematic Review	United States	To examine the major industry lessons that have been applied to healthcare, look at some successful approaches to increasing efficiency, discuss some of the challenges particular to pediatric surgery, and make some recommendations for consideration by individuals interested in improving any aspect of OR efficiency.	all OR efficiency has a local component, and while many strategies discussed in this manuscript are generalizable, each institution must review its particulars and adopt these strategies.
5	Daniel J. Lee, et al,.(2019)	Systematic Review	USA	To view inefficiencies in how operating rooms are utilized.	Recent Findings Recent innovations utilizing patient-centered data, systems principles from manufacturing industries, and enhanced communication processes have made significant improvements in improving operating room efficiency
6	Marc A Ellsworth, et al,.(2017)	Systematic Review	USA	To evaluate methodological and reporting trends present in the current literature by investigating published usability studies of electronic health records (EHRs).	demonstrates a paucity of quality published studies describing scientifically valid and reproducible usability evaluations at various stages of EHR system development. A lack of formal and standardized reporting of EHR usability evaluation results is a major

					contributor to this knowledge gap, and efforts to improve this deficiency will be one step toward moving the field of usability engineering forward
7	Isaac H. Goldstein, BA,et al,.(2019)	Cohort study	USA	to examine how the amount of time spent using EHRs as well as related documentation behaviors changed 1 decade after EHR adoption.	After 1 decade of use, providers spend more time using the EHR for an office visit, generate longer notes, and close the chart faster. These changes are likely to represent increased time and documentation pressure for providers. Electronic health record redesign and new documentation regulations may help to address these issues
8	Zhen Yu Liu, et al,.(2019)	retrospective study	Australia	to determine whether the introduction of EHR systems resulted in changes in documentation quality and other markers of clinical performance such as post-operative length of stay (PO LOS), use of imaging modality, rates of readmission, and morbidity	This study demonstrated that following the implementation of the EHR system in an inpatient surgical ward, notation quality improved. It was also found that the implementation of EHR was associated with a decrease in PO
9	Rebecca M. Jedwaba, et al,.(2019)	Scoping review	Australia	To identify measures useful to evaluate the nursing benefits of electronic medical records implementation in the Australian hospital context.	Measures useful to inform a quality assessment framework to examine nursing benefits of electronic medical records in Australian hospitals. The next steps include testing the validity, reliability, and sensitivity of indicators to evaluate the impact of an implementation strategy. Future research should identify measures to examine the quality of individualized care
10	M. Mitteregger, et al,.(2020)	Retrospective study	USA	to determine whether a single tool alone can significantly improve codes.	Implementation of shop floor management as a single intervention is not appropriate to achieve a significant, continuous improvement in codes. A combination with other techniques such as detailed process analyses is

					required. This could be important additional information for units using Lean Health Care strategies.
11	Albert Wu, et al,.(2017)	Retrospective study	Francis St., Boston	To evaluate the effect of deploying a new electronic medical record (EMR) system on the first case starts in the operating room	EMRs have the potential to improve hospital workflows but are not without learning curves. FPIR and FCOTS delays return to baseline after a few months, and in the case of FCOTS, can improve beyond the baseline
12	Shawne Olson, et al,.(2018)	Literature review-Retrospective data	USA	To improve operating room efficiency without requiring additional resources. To address operating room efficiency	This quality improvement initiative demonstrates the ability to reduce a turnover time for patients having a total joint replacement with spinal anesthesia by changing patient flow with no additional human or capital resources.

Discussion

EHR or electronic health record is a systematic collection of electronic-based health information that is connected and integrated with information systems in the hospital network. The use of an EHR system is the key to a comprehensive strategy to improve healthcare quality, effectiveness, efficiency, and patient safety. Several measures of operating room efficiency can be viewed from multiple stakeholder perspectives, such as nurses, surgeons, anesthesiologists, patients/families, hospital administrators, regulatory agencies, and payers. Most institutions will choose a different combination of metrics based on local metrics. Some evaluations of the benefits of implementing an EHR system relate to the quality of health services and safety benefits. The shift or transition of documentation from paper-based or traditional documentation to electronic documentation (EHR) has had a significant impact on operating room efficiency. The proposed advantage of newer EHRs is that they minimize hospital workflow and improve billing data retrieval. The pre-implemented legacy system consists of paper and electronic records. Data entered in the EHR is completed through a combination of paper records and computerized checklists.

According to the Canadian Pediatric Center in 2007 identified several operating room efficiency metrics. As the number of procedure cancellations or unforeseen cancellations increases, the time to start the first surgery (FPIR) will also be delayed and patient readiness (FCOTS) will also be delayed. These two metrics are often used to measure operating room efficiency.[6] Previous studies have shown a significant relationship between EHR system implementation on FCOTS and FPIR metrics, both of which are very important measures in measuring operating room efficiency.[12,15] The effect or impact on efficiency metrics may not be the same in other places or institutions because they adapt to different workflows, legacy systems, or different EHRs from their implementation strategies. Depending on the EHR system itself, periodic updates are possible in the evaluation as well as having the ability to measure EHR usage. Evaluation of the benefits of the EHR system needs to be observed in line with the multifactorial components of hospital care. The implementation of EHR must also pay attention to the desired and undesirable effects on the quality of maintenance work. In turn over time, EHR can also improve the quality for patients undergoing long anesthesia, so that in data collection, analysis or making reports that are ongoing during surgery.[16]

When reviewing published research from the last five years showing the effect of the EHR system on the cost of care, few studies address this aspect head-on. The shift of health services from paper-based manuals to electronic information systems creates cost savings in hospitals, especially in operating rooms. This is explained in previous research, that the use of EHR further optimizes time resources in cost savings.[17] In addition to costs, EHR can also provide benefits in documentation time, where the quality and quantity of nursing time in carrying out nursing documentation is more consistent and orderly in achieving professional standards and decreases the time for nurses to do documentation after introducing this EHR system and more efficient and communication with patients or family is more effective.[9] In previous studies it was explained that the increasing focus on the quality of documentation with more detail requiring documentation of the nursing process has led to increased pressure and staff dissatisfaction.[6] In addition, EHR can assist nurses in providing information to patients and is very useful in community health centers.[17] Nursing quality is one of the factors in operating room efficiency. With the EHR system, the quality of nursing can be measured so that it can produce nursing values that can influence clinical nursing practice.[18]

Conclusion

Evaluation of the usefulness of the EHR system is an essential component of putting electronic devices in the hands of clinical providers because they can contribute to the effectiveness of health care and quality of care. Besides that, EHR also provides access to information at the time and place needed by health workers. This has an impact on health workers and health service agencies. Nurses are one of the human resources in inputting the EHR system and nurses are expected to realize the importance of implementing technology in health services so that they are willing to learn during its implementation. For health service agencies, it is also expected to do the same because of the demands of the times and the many positive things that can be obtained. A health service manager can create a special team to be able to adopt or implement technological developments so that health workers, especially nurses, are ready to apply to health care organizations.

Conflicts of Interest Declaration

This research is free from conflicts of interest, both individuals and organizations

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