

## Original Research Article

# Examine the impact of the implementation of an electronic medical record system on operating theatre efficiency at a teaching hospital in Australia

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## ABSTRACT

**Background:** The utilization of electronic medical record (EMR) system has become the mainstay of healthcare system in developed countries. In the last five years, Queensland Health has gradually implemented EMR system for hospitals in Queensland, Australia. As far as we are aware, no study has been conducted to assess the impact of the EMR implementation on operating theatre efficiency in Australia.

**Methods:** A retrospective review of general surgery operating room on time start data was performed for a period of 2 months prior and 2 months following implementation of the EHR. A delay was defined as the time between the scheduled start time and “first in” times. Outcomes measured included the total number of sessions run, number of sessions starting late, average delay time and case cancellations.

**Results:** During the EMR training period, the number of sessions which had delayed increased from 13.2% to 31.0%. Following implementation of the EMR, delays were present for 88% of sessions for the first month with an average delay time of 21.8 minutes. The second month showed an overall improvement with 69% of sessions delayed and a reduced average delay time of 10.4 mins.

**Conclusions:** The implementation of a new electronic medical record system is associated with delays in theatre start times especially during the training period and first month of use. Evidence of recovery of service efficiency however is seen by the second month post-implementation with further expected improvement if trends continue.

**Keywords:** Australia, Implementation of an electronic medical record, Theatre efficiency

## INTRODUCTION

In the last few decades, the utilization of electronic medical record (EMR) has become the mainstay of healthcare system in developed countries.<sup>1-8</sup> An electronic medical record is a systematic electronic collection of health information about patients such as medical history, medication records, investigations, and inpatient and outpatient documentations. The aim of EMR is to utilise information technologies to deliver healthcare and

address the health problems and challenges faced by health professionals efficiently.

In the last five years, Queensland Health has gradually implemented EMR system for hospitals in Queensland, the sunshine state of Australia. Ipswich hospital is a 351 beds metropolitan hospital situated 40 kilometres west of Brisbane. It is a multispecialty hospital in which offers general surgery; orthopaedic; urology; ear and throat surgery; plastic surgery; obstetrics and gynaecology; anesthetic; intensive and coronary care units; emergency

medicine; general medicine; paediatrics, palliative care, rehabilitation; mental health; and a full range of allied health services.

Campanella et al, has conducted a meta-analysis to assess the impact of EMR on healthcare quality.<sup>2</sup> It has demonstrated that the use of EMR can improve the quality of healthcare, increasing time efficiency and guideline adherence and reducing medication errors.

Concerns over EMR adoption however, have been raised in many aspects of clinical practice such as increasing time requirements, workflow disruption, and negative impact on clinical volume and patient care.<sup>3,4</sup> Previous studies had shown that documentation in EMR could take longer than paper record.<sup>5</sup>

Nguyen et al, had also conducted a systematic literature review to analyse the impact of electronic health system and aim to describe the system attributes, levels of use and patient and users' satisfaction, and contingent factors relation to system implementation.<sup>4</sup> Mixed findings of positive and negative impacts were found in many aspects of clinical settings.

Overall, it was found that there is improvement of documentation quality, increased administration efficiency and better quality, safety and coordination of care. However, there are also negative impacts included changes to workflow and work disruption.

It is believed there is a learning curve for efficient use of EMR and it is known that the operating room is one of the most expensive areas in hospital.<sup>9,6</sup> Therefore, assessing the impact of EMR implementation on operation room efficiency has also become a hot topic as the diminished efficiency would increase in healthcare cost, scheduling difficulties, and patient dissatisfaction.

Sanders et al, had conducted a prospective cohort study to investigate the impact of EMR on documentation time, surgical volume, and staffing requirements in ophthalmology specialty.<sup>3</sup> It concluded that EMR implementation is associated with worsening of intra-operative nursing documentation time especially in shorter procedures but no serious negative impact on surgical volume and staffing requirements.

McDowell et al, also had performed a study to evaluation the effect of EMR on operating room efficiency and surgical case turnover time.<sup>6</sup> It was noted there was a significant increase in turnover time and decrease in efficiency in which it took five months to achieve baseline (pre-implementation).

In transition to an EMR use, few months preparation was undertaken for all hospital members. This included lectures from the EMR training staffs or staffs that had already utilised EMR; learning online modules; and online assessment prior to use of EMR.

On time first case start is a recognised quality parameter and is often the reflection of overall operating room efficiency.<sup>1</sup> 'Wheel in' on time of 59% is a recognized benchmark. In our study, we aimed to evaluate the impact of EMR implementation on efficiency of operation room by assessing first case start time. We hypothesized that the implementation of EMR will decrease the efficiency of operative room initially but improve within few months.

## METHODS

This study was performed in a major acute teaching hospital in Queensland, Australia between September 2018 and January 2019. Retrospective analysis of operating theatre data was performed reviewing all general surgical data for a period of four months. This included the four weeks prior to the EMR training period (recorded as baseline performance), the four weeks of mandatory EMR training and eight weeks following implementation of the EMR system. The start time of first case in the morning was recorded and analysed. A delay was defined as the time between the scheduled start time and "first in" times. A "late" session was defined as any session for which the "first in" time was  $\geq 1$ min over the scheduled time. Only morning or all-day sessions were included and afternoon sessions were excluded as delays may be confounded by delays from the preceding morning session.

Outcomes measured included the number of delays, the proportion of sessions delayed and the mean time delay for the first case.

The data was obtained from surgical theatre database (ORMIS) prior EMR implementation and SURGINET program post-EMR implementation.

Statistical analysis was performed using Prism 8 (Graphpad Inc. 2018). Fishers Exact Test and Mann-Whitney tests were used to determine statistical significance with a p value  $\leq 0.05$  considered a significant result.

This project was reviewed by West Moreton Human Research Ethics Committee and it was deemed to be compliant with National Health and Medical Research Council (NHMRC) guidance 'Ethical Consideration in Quality Assurance and Evaluation Activities' 2014. Therefore, a formal Ethic Approval was not required.

## RESULTS

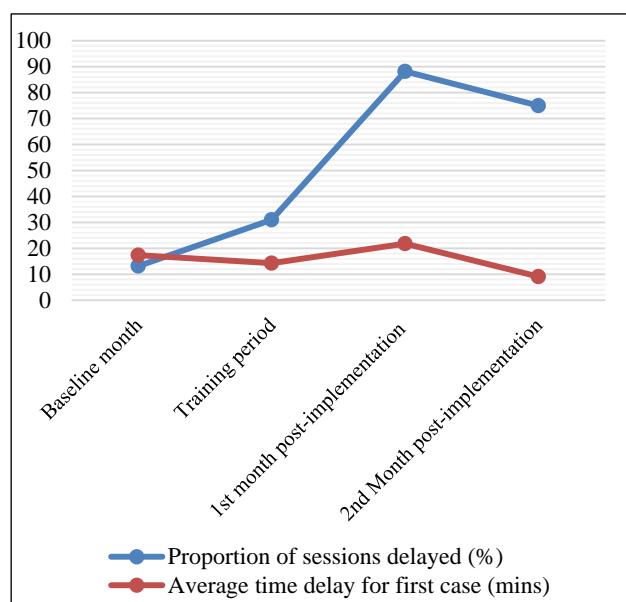
In the 4 weeks preceding, the EMR training period, the number of sessions which had any delay was 13.2%. The average delay was 17.4minutes. During the training period, the number of sessions decreased from 38 per month to 29 per month with the percentage of included sessions delayed increased to 31.0%. This however was not statistically significant (p=0.102).

Following implementation of the electronic medical record system, the total number of sessions was intentionally decreased and coincided with an extended holiday period. 17 sessions were included with delays to 88% of sessions with an average delay time of 21.8 minutes. This represented a significant increase in session delays ( $p < 0.0001$ ) compared to the baseline figure. This can be appreciated graphically in Figure 1. The second

month following implementation showed an overall improvement in delays with 69% of sessions delayed with a reduced average delay time of 9.1 minutes. When compared with the first month of implementation, the improvement was statistically significant ( $p = 0.0408$ ). Table 1 gives a summary of session delays stratified into implementation periods.

**Table 1: Summary of session delays based on EMR implementation phase.**

	Baseline month	Training period	First month post-implementation	Second month post-implementation
<b>Total included number of sessions</b>	38	29	17	16
<b>Number of late start sessions</b>	5	9	15	12
<b>Proportion of sessions delayed (%)</b>	13.1	31.0	88.2	75.0
<b>Average time delay for first case (mins)</b>	17.4	14.3	21.8	9.08



**Figure 1: Session delays and average time delay.**

## DISCUSSION

Electronic health care is a well recognised as costly investment. The implementation of EMR requires a considerable commitment of time and money by hospitals and medical staff. Reports in the literature quote cost of EMR implementation in first year per physician at over USD 46,000 for personal computers, software, licensing and maintenance and up to USD 120,000 per physician when lost revenue was accounted for. In addition, approximately \$ 28 billion per year of initial cost in the United state was estimated by some studies.<sup>11,12,6</sup>

Campanella et al, however, have shown that EMR can reduce the costs associated with medical errors, adverse drug effects and time inefficiency.<sup>10</sup> In fact, it had shown that appropriate use of EMR can improve hospital

efficiency with benefits exceeding the costs of adoption and patient satisfaction rating.

In addition, it was found that EHRs has advantage of management of chronic diseases such as diabetes quality of care, osteoporosis management and antimicrobial stewardship.<sup>6</sup>

Queensland health EMR is the leading digital healthcare innovation in Australia, In Queensland, Sunshine state of Australia, there were 8 digital hospitals prior to 2018 and Ipswich hospital was one of four hospitals in Queensland to become digital in 2018, with the aim of 27 hospitals by June 2020.

The EMR delivers an integrated suite of digital health care services that improve safety, efficiency and quality in clinical workflow processes. This program has developed through several stages and changes in scope.<sup>9</sup> The initial concept of eHealth strategy was developed in 2006 and the first trial of EMR implementation in public hospital occurred in 2015.

Some studies have shown a potential cost saving of more than \$81 billion annually from EMR.<sup>6</sup> According to Queensland hospital website, data analysed from first 5 of digital Queensland health had shown an 88% reduction in pressure injuries and 37% reduction in hospital acquired infections.<sup>10</sup>

It has been shown there is \$181.9 million financial and economic benefits achieved since implementation of EMR in the first three years. It is estimated that significant annual benefits may occur \$ 4.2 million in stationery savings; \$10.5 million reduction in diagnostic tests; \$6.7 million in pathology tests; \$10.4 million reduction in drug costs; 1321 avoided hospital readmissions; 26,422 bed days saved; and 5209 avoided clinical incidents.

Despite various audits demonstrating the benefit of EMR, no study has yet to assess the impact of EMR implementation on operating theatres in Australia. Prior to implementation some staff at our institution questioned the effect of the digital system on the flow of operating room with potential disruptions further affecting its efficiency. This is significant given operating theaters are known to be a significant area of resource allocation and an important indicator of a hospital's overall efficiency.

Our results indicate that there is a significant increase in theatre start delays in the first month following implementation even with reduction in service volume. However, by the second month efficiency is already statistically significantly improved. This improvement is likely multifactorial and may represent a combination of effective training regimes, appropriate service reduction to allow for adjustment and system adaptation to changes resulting from EMR implementation. Of note there was not a significant increase in delays over the 4 week training period, which again is likely attributable to a variety of factors including changes of staff roster, extended hours available for training and awareness of adjustments required to account for training requirements.

Frazer et al, had conducted a study to investigate the impact of EMR implementation on operating room efficiency from the United States.<sup>1</sup> In his study, they have undertaken a six-month training program including video presentations and lectures for all medical members. It was found that the on time starts ranged from 59-69% with a mean of 64% in the three months prior to initiation of the EMR. Following EMR implementation, on time first starts dropped to 41% in the first month, and incrementally improved to baseline levels by the fourth month after EMR adoption. After the 4<sup>th</sup> month, first start efficiency continued at the baseline ranged of 59-69% for the remainder of the calendar year. This difference achieved statistical significance with  $p < 0.01$

The cause of delay was analysed. 70% of the delays were due to incomplete orders or charting secondary to inexperience with the different components of EMR documentation.

As mentioned before, most of studies investigating the impact of implementation of electronic health record were originated from the United State. These were largely due to its unique healthcare system as hospital in America were mainly in private setting and majority of electronic medical record systems were owned by private companies. Bias of the result could incur as those private companies would have the intention to show the positive impact of EMR to the healthcare system. It was also noted that incentive payment occurred in the united state in order to encourage the process of implementation. In Queensland, only one EMR system was applied in the public hospitals. This has reduced the risk of bias as no

incentive payment was given during the implementation of EMR.

The efficiency of operating room is determined by its productivity and utilisation of theatre. Operating room efficiency management relies on generating an accurate schedule by adjusting time allocation, prompting on time case starts, and controlling turnover time (TOT) between cases.<sup>6,8</sup> McDowell et al, believed TOT was one of the most effective ways to assess the efficiency of surgical room as it typically has less impacted by patient-specific and technical issues factors.<sup>6</sup> His study showed the implementation of an EMR led to a significant decrease in efficiency for the first five months and returned to baseline at 6 months. Although the mean TOT had never improved beyond baseline during its study time, McDowell et al showed no significant different in average number of total cases per day and indeed, he believed that EMR can lead to improvements in operating room scheduling.

There were also few studies done by ophthalmologic team reviewing documentation in the operating room as it has high volume and short duration of ophthalmologic operations. Sander et al, had suggested that the intraoperative nursing documentation time was significantly longer after electronic medical record system implantation.<sup>3</sup>

Sander et al, also used parameters of surgical volume and total operating room staffing to assess the efficiency of the theatre.<sup>3</sup> It was found that no significant change occurred before and after the implementation of EMR. In our study, during the transition of EMR implementation, case volume had been reduced in order to avoid significant delay/cancellation to cause negative impact on patient's care. This limited the ability to demonstrate a statistically signify change in operative volume with EMR implementation. Hence, the change in operative volume was not a reliable measurement to assess the effect of EMR in our study.

The reduction in efficiency of surgical room during the implementation of EMR was attributed by several factors. Firstly, there is an inevitable learning curve during the new system implementation. Secondly, slower documentation method in EMR compared to paper-based forms (e.g. using point-and click EMR is slower than paper-based forms), and lastly, overall documentation volume required by the EMR system was greater than the baseline paper system.

There are several potential study limitations in our study. Firstly, as it was a retrospective study, we were unable to control various factors, for instances, case scheduling or reduction of surgical case volumes. We were also unable to analyse the underlying causes for the increased delays. Secondly, our timeframe of study period may not be long enough to fully assess the impact of implementation of EMR in efficiency of operating room as we have not yet

to see its efficiency to return to baseline. Thirdly, the number of surgical cases in our single centre hospital may not be large enough to represent the impact of EMR to all digital hospitals. Lastly, our study only assessed general surgical operating theatre rather than other subspecialties, indicating the findings may not be generalizable to different specialties or different hospital.

Other measurements can be considered for future studies include anesthesia control time and surgical control time as they are important components of operating room workflow.

## CONCLUSION

The implementation of a new electronic medical record system is associated with delays in theatre start times especially during the training period and first month of use. Evidence of recovery of service efficiency however is seen by the second month post-implementation with further expected improvement if trends continue.

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