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Anaesthesia Electronic Records Versus Handwritten Anesthetic Records: An Ambi-directional cohort study

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Abstract

Background: Handwritten documentation process has drawbacks. Therefore, anaesthesia electronic record (AER) is becoming commonplace in operating theatres to help clinicians improve perioperative quality. This study aims to evaluate the efficiency of AER are compared to handwritten records in terms of completeness of information, time and cost, and assessing user satisfaction.

Methods: A hospital-based cohort study was conducted, which was an Ambi-directional study that included a phase 1 part of the study that was retrospective (using a checklist) and phase 2 that was prospective (using a questionnaire at King Faisal Specialist Hospital and Research Center, Riyadh (KFSHRC), Saudi Arabia. For phase 1, data were collected for 165 handwritten records during 2016 – 2017 and 77 AERs during 2018 – 2019, both from the operating room at KFSHRC. For phase 2 survey was conducted on 47 anaesthetists.

Results: The AER shows significantly higher completion of information than the handwritten records (AER: 62.3% versus handwritten: 48%; P = 0.02). In terms of time, the meantime for the handwritten report was 45.9 min compared to 53.9 min for AER, therefore, showing the handwritten method's efficiency compared to AER. The satisfaction survey found that 53% of the respondents recognise the growing role of AER in streamlining workflow and improving the quality of services.

Conclusion: The study demonstrates that AER has better completion of information, which supports the enhancement of documentation quality. On the contrary, lesser time is taken for filling handwritten records than AER, therefore, handwritten records are cost-efficient. This also shows how the time spent impacts the cost in operating theatre. We recommend a user-friendly environment for AER with adequate training for its users.

Keywords: Anaesthesia; Informatics; Electronic health record; completeness; time; Cost-efficient; Saudi Arabia.

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1. Introduction

A detailed anaesthetic record is essential to anaesthetic care. The requirements for maintaining a record are outlined in the Professional Document PS6 issued by the Australian and New Zealand College of Anesthetists [1]. Anaesthetic records were first implemented in 1894 by two medical students, Harvey Cushing and Amory Codman [2],[3]. In addition to being an accurate guide to Operating Room (OR) subsequent patient care, an accurate medical record also provides factual data that can be used for quality assurance and research [4],[5]. Additionally, complete records have significant legal implications for costing and billing calculations and play an increasing role in medical litigation [6-12].

An electronic form of anaesthesia record in the electronic health records systems (EHRs) has proven beneficial because of its accessibility from any computer [13],[14]. The evolution of the record from handwritten to electronic form has advanced these roles while at the same time bringing forth new benefits and challenges [14]. It has proved that enhancing patient safety and guaranteeing effective, efficient, timely, equitable, and patient-centred care impacts healthcare quality [15]. Numerous anaesthetic electronic record systems (AERs) have been found in the literature reporting how these systems improve on the deficiencies found in the handwritten approach [16-19]. Thus, AER is proved to have better data quality and the ability to meet the expectations of anaesthetists. AER aids in decreasing missing essential preoperative and postoperative information [20].

To the best of our knowledge, AERs have been studied scarcely in the context of Saudi Arabian hospitals. No study has been published on this topic. Especially there is a need for a study that analyses AERs from the perspective of their cost, time to use them, and their ability to report complete information compared to handwritten Anesthesia records used in Saudi Arabian hospitals. This study will help to understand the difference between using AER. and handwritten records and see how the time utilized filling hard written records in the operating room costs the hospital and impedes service quality. Therefore, the objective of this study was to compare AER to handwritten records in terms of saving time and cost and ensuring completeness of information assessment. We also intended to assess the user satisfaction towards the AERs.

2. Subjects and Methods

2.1 Study design and setting

The data for the current study were derived from a hospital-based Ambi-directional (both retrospective and prospective phases) cohort study, conducted at King Faisal Specialist Hospital and Research Center (KFSHRC), Riyadh, Saudi Arabia. The aim of this study, as per their design, are stated below:

A. Retrospective cohort cross-sectional design:

This study phase compares AER to handwritten records based on completeness of information assessment, time taken to fill the record, and cost. The study was conducted in the operating theatres for the general surgeries department at KFSHRC.

B. Prospective cross-sectional design:

The study's second phase was a self-administered cross-sectional survey conducted on anaesthetists working at KFSHRC to assess the user experience and satisfaction towards the AER implementation. Inclusion criteria for these anaesthetists were that they must be practising in the same hospital for more than three months as an anaesthetic consultant or assistant.

2.2 Data collection

A. Retrospective cohort cross-sectional design: Comparison of AER versus handwritten records

1. Completeness of information assessment: The data was collected for this phase using a checklist list comprising of 10 items, which is an adaptation of ANZCA's Recommendations on the Recording of an Episode of Anesthesia Care [1, 21], to measure the accuracy and clarity of anaesthetic record documentation [22, 23] (see Appendix 01). The data was collected for 165 handwritten, physical records of ASA II procedures from operation theatres of the general surgeries department at KFSHRC, conducted during 2016 - 2017. Furthermore, to study the electronic records for comparison, data of 77 electronic records of ASA I, II, and III procedures were selected and accessed via Cerner (EHRs) implemented at KFSHRC. These cases were particularly cases of cholecystectomy open and laparoscopic cholecystectomy conducted during 2018 – 2019. Each recorded anaesthetic data was scored as 1 if the information is completely documented, 0 if no information is documented, and 0.5 (1/5) if the information is incomplete.

2. Time and cost: Time and cost were calculated and analysed using the following formula for both the handwritten and AER [24].

Anaesthesia duration – Surgery duration = Anesthesia Time ……. (Eq.1)

For definitions, See Table 1. Where time was documented in minutes to calculate the cost in an operating room, is estimated as (1 minute = 62$) that is: [24]

Anesthesia Time * 62 = Cost in OR room……. (Eq.2)

Table (1) Definitions of terms to calculate time and cost

Terms	Definitions
Anaesthesia duration (starts to end)	It is the time duration (calculated in minutes) when the anaesthesia procedure starts to be induced to the patient until it finishes, and the patient starts recovering from the anaesthetics.
Surgery duration	The time duration (calculated in minutes) starts with the incision when the surgeon applies a knife to the skin and stops with wound closure.

B. Prospective cross-sectional design: User satisfaction survey

The data for this phase was collected using was a self-administered questionnaire-based survey conducted on 75 anaesthetists working at KFSHRC during April – May 2019 to assess the user experience and satisfaction towards the AER implementation. The study questionnaire was developed in English and adapted from previous work [25-27]. The questionnaire included 30 questions categorised into five main sections, i.e., General demographic information, AER medical practices use, AER versus Handwritten record, a comparison from the user's point of view, usability of AER, and AER user satisfaction. In addition, the questionnaire was validated through the pilot study feedback to ensure the understanding, design questions, and workflow of the study. A Cronbach alpha of more significant than 0.6 was also determined for the instrument reliability.

2.3 Data Analysis

The study data were collected and entered a computer using standardised entry codes. For all tests, statistical $P < 0.05$ was assumed to be significant. Descriptive statistics were used to present means, standard deviations, and percentages. In addition, t-test was employed to compare the handwritten records and AERs, for mean difference and variance calculations. All analyses were conducted in SPSS version 25 (SPSS Inc, Chicago, IL, USA).

2.4 Ethical Statement

All participants were informed about the aim of the study, and their consent for participation was recorded. The Institutional Review Board approved the study at the College of Medicine, King Saud University and King Faisal Specialist Hospital and Research center to conduct the study and access relevant data. Data were collected according to the Helsinki declaration for Human subject study guidelines [28].

3. Results

3.1. Overall completion of information assessment

The overall mean percentage compliance score of 76% and 88% was recorded for handwritten records (n=165) and AER (n=77). When an independent sample t-test was applied, assuming unequal

variance, it was found that AERs outperformed handwritten records in terms of completeness of information assessment (P = 0.34). Based on the assessment scoring checklist (see Appendix 01), data for item intravenous infusion was recorded as 100% complete in AER compared to handwritten, where it was completed in 89% of the records. AER followed the anaesthetic technique and medication details in 95% of the records, the difference being statistically significant (P = 0.07) compared to handwritten records. In handwritten records, 88% and 88.5% of cases reported anaesthetic technique and medication details, respectively. A statistically significant difference was observed for blood loss data (P = 0.02) between handwritten data and AERs. Time was less likely to be documented in the handwritten record, as it was documented only in 55% of these records. Time was recorded 93% times in AER. Astonishingly, it was observed that monitoring was recorded 67% of times with AER compared to handwritten records, where it was recorded in 78% of records (P = 0.016). Monitoring was the only output where the handwritten records outperformed the AER for completeness of information assessment. (See table 2 for details).

Table (2) Completeness of information Scores

No.	Items	Handwritten Records (%)	AER (%)	*P*-value
1	Anesthetic technique	88	95	0.07
2	Medication	88.5	95	0.07
3	Airway	88.5	93.5	0.18
4	Breathing system	88	93.5	0.16
5	Monitoring method	78	67	0.016
6	Intravenous infusion	89	100	0.18
7	Blood loss	48	62.3	0.02
8	Time	55	93	0.6
9	Complications and problems	88.5	93	0.3
10	Other Information	76	93	0.9

3.1.2 Mean Time and Cost analysis

For the collection of handwritten records, it was observed that the anaesthetist's team adapted poor compliance of time documentation during their paper documentation process. However, the data was also being collected by the attending surgery team, using SurgiNet (a module of Cerner)[29] for their documentation records. Therefore, the data for time calculation was chosen for 98 cases that were documented both by handwritten and via SurgiNet. Using the formula see (Eq. 1), handwritten records (n=98) and AER (n=77) were tabulated and analysed for Time analysis. Independent sample t-test assuming unequal variances was applied to calculate the mean difference and the variance (See Table 4). The results of the Time calculations were then further analysed using the formula (Eq. 2) to calculate the cost for each case in the operation theatre. According to [24, 30], the cost calculated in surgical procedures

is the time spent in the operating theatre, thus estimated as 62$/Min. With an average of eight minutes as an advantage of the handwritten records, it was therefore found that handwritten records will save around 496$ of cost during the procedure in the OR (See Table 3). Hence, it shows the efficiency of the handwritten records in terms of time computation and ultimately cost efficiency over the AER.

Table (3) T-test: two-sample assuming unequal variances to calculate Time and Cost Analysis

	Time Analysis (Eq. 1)		Cost Analysis (Eq. 2)	
	Handwritten Records (n = 98)	AER (n=77)	Handwritten Records (n = 98)	AER (n=77)
Mean	45.9	53.9	2846.3	3343.97
Variance	152.6	285.9	586910.37	1099316.99
Observations	-	-	98	77
T - Stat	-3.4		-3.49	
P(T<=t) two-tail	0.0006		0.0006	

3.2 User Satisfaction

3.2.1 Response Rate and Demographic Information

Of the 75 participants we approached to participate in the study, 47 (63%) completed the survey. Most of the participants, 43 (92%), were male. The overall mean age of participants was 52.2 (SD 8.9) years, and most of them were anaesthetic consultants (38/47, 80%). The overall mean work experience of the participants was 9.4 (SD 7.4) years.

3.2.2 AER medical practices use

Most of the participants (63%) agreed to use AER "always" to review their patients' problems, and (38.2%) agreed to use AER on "most of the occasion" to assist in following the results of a particular test or investigation over time, and to perform their ordering. Likewise, most of them (49%) agreed to "always" use MACRO functionality for their documentation. More than half (53%) reported using AER "most of the occasion" to get real-time information.

3.2.3 AER versus handwritten records: A comparison from the users' point of view

When participants were asked to compare the anaesthesia paper records versus AER, more than half of the participants (32/47, 68%) strongly agreed that AER had closed the gap of medication documentation in the OR area. Thirty-six [36/47, 77%] of the total participants strongly agreed that AER had eased medication capture and documentation; and has eased vital signs capture and documentation automatically [40/47, 85%], which has provided accuracy and has helped save time. On further comparison, (26/47, 55%) strongly agreed that AER system with decision-support features helps in medication decision making and documentation, and (32/47, 68%) strongly agreed that AERs helps in conflict checks to support accuracy before case finalisation.

3.2.4 Usability of AER

This section asked regarding the AER functionality's easiness, friendliness, and efficiency. On inquiring about the AERs Bed Side Medical Devise Interface feature, 37/34 (79%) of the respondents strongly agreed that it helps capture and monitor parameters automatically while eliminating manual documentation, therefore, saving time. Furthermore, whereas only 26/47, (55%) the documentation output is in a proper format, the system is "most of the occasion' is user friendly (22/47, 47%), and easy to use (21/47, 45%).

3.2.5 AER User satisfaction

Satisfaction refers to how pleasant it is for the user while using the system [31]. In context to the definition, the satisfaction level towards the AER system was assessed. Most of the responded participants showed satisfaction with the system. They believed that the information is "most of the time" is up to date (28/47, 59.6%), shows access to the content that is needed (26/47, 55.3%), and is clear and sufficient (24/47, 51.1%) (Figure 1).

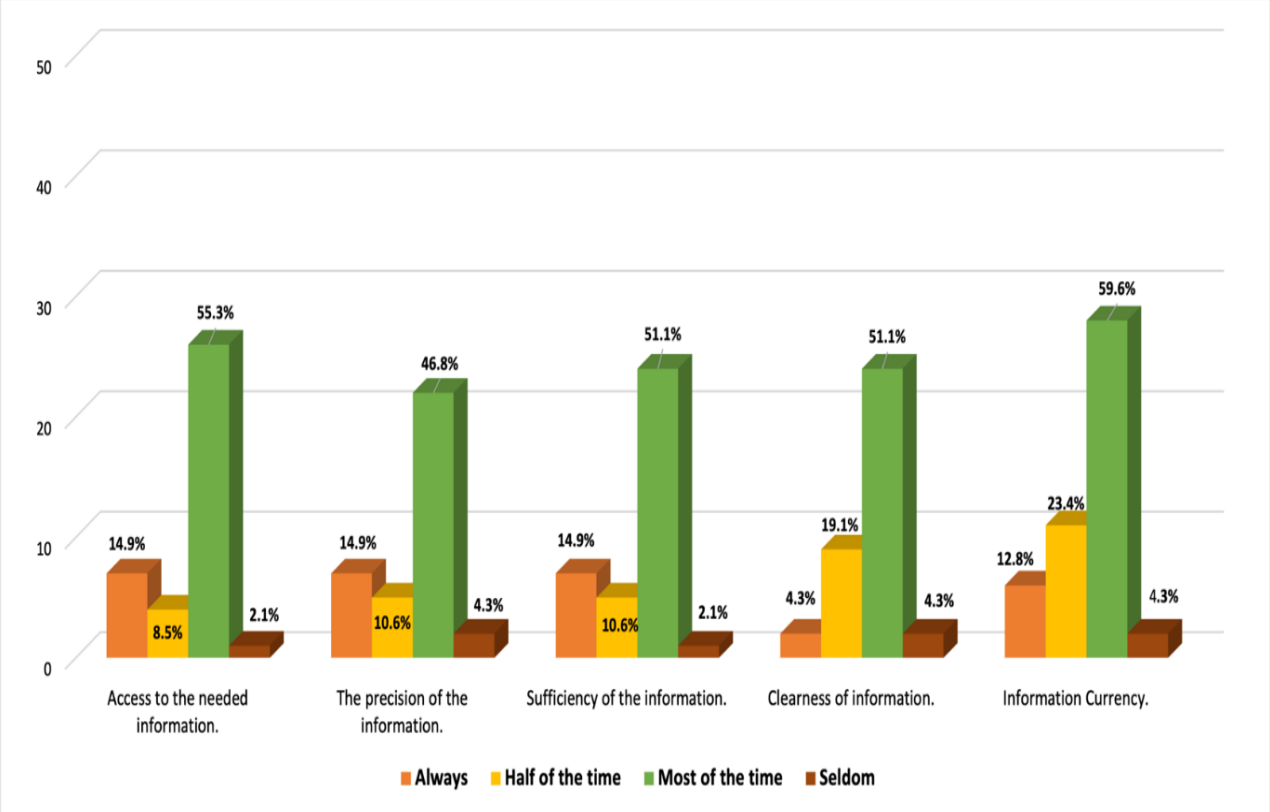

Figure (1) Satisfaction level with the system with regards to the Information accessed

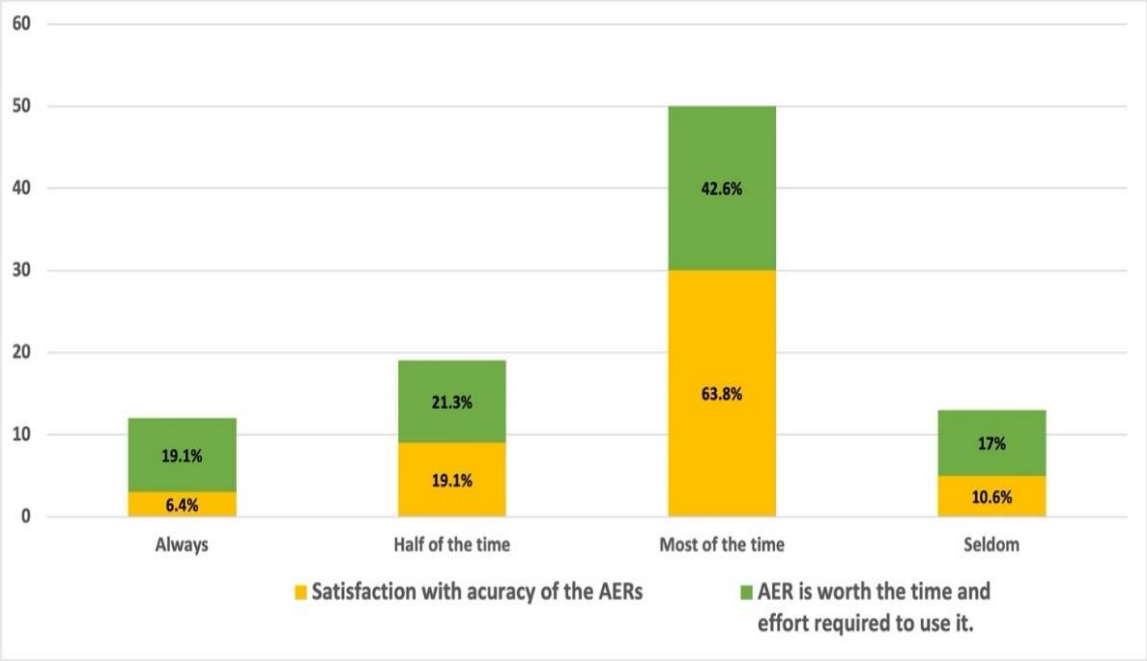

Figure (2) Satisfaction level with the AER system

Over half of the participants (30/47,63%) expressed satisfaction with the accuracy of the AER system, and (20/47, 42.6%) said that it is worth the time and efforts required to use it (Figure 2). Furthermore, more than half of these individuals (25/47, 53%) felt that AER had increased the quality and performance (Figure 3). In addition to grading the AERs in their department as "very good/good", 31/47 participants (66%) affirmed their satisfaction with the support and training their hospital provided, whereas 12/47 (26%) disagreed with this. (Figure 4).

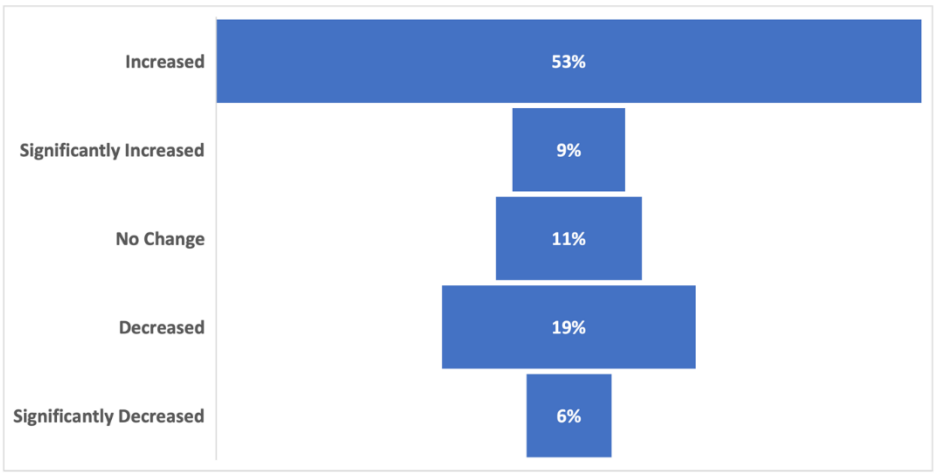

Figure (3) Quality and performance of participants workflow with AERs

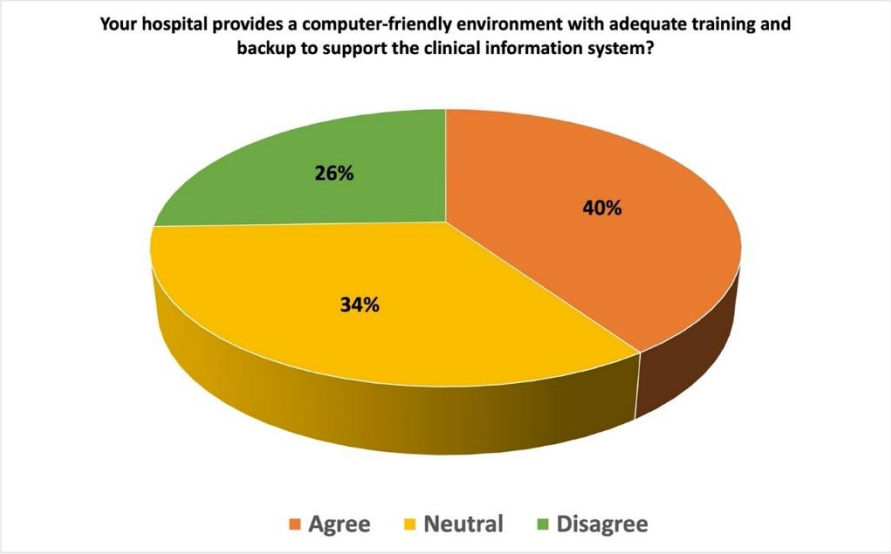

Figure (4) Support and training for hospital participants with AERs

4. Discussion

AER is adopted mainly to improve the anaesthesia workflow by utilising the digital transformation features and eliminating the drawbacks of the manual workflow. In this Ambi-directional cohort study, we evaluated the efficiency of AER compared to handwritten records in terms of time, cost and completeness of records. We also assessed the user experience and satisfaction towards the AER system.

The results of our study showed that AER has a significantly higher completion of information rate than handwritten records. Among the items for assessment, intravenous infusion, anaesthesia technique, blood loss and medication details were better recorded in AER than the handwritten record. However, monitoring was better recorded in handwritten as compared to AER. The results of the completeness of information of this study are in line with another study. Their results showed that anaesthesia management records were more accurate than the handwritten records for 32 predefined items. Thus, the potential of observational research to influence professional behaviour in an anaesthetic context was confirmed [22]. Another study assessed the completeness of information of 2,838 electronic records and found that their system continued to lack important clinical information [32]. However, to the best of our knowledge, no study has compared AER with handwritten records in Saudi Arabia regarding efficiency, completeness, and user satisfaction. Generally, the ability to enforce required data recording is unique to computerized records. An Anesthesia record is a basic form of communication between various staff involved in a patient's care and an essential record for audit and legal purposes. In this study, the AER records contained complete intraoperative information compared to the paper record.

"How much does one minute of OR time cost?" is a question often asked in the OR suite. The answer to this question is contextual and depends on multiple factors [33]. In the OR, the cost is defined

as a resource sacrificed to achieve a defined goal [34]. Based on our results, using the formula (Eq.1) [24], time was documented and evaluated in minutes to check the cost in the OR (1 minute = 62$). All AER and handwritten records had time information for the anaesthesia. However, this finding differed from a previous cohort study comparing electronic records with a paper record. In that study, both "anaesthesia starts to scope insertion" times and "scope removal to transfer" times were significantly less in the Epic (electronic) group compared to the paper group.

The use of the Epic system led to a saving of 4 min of procedure time per patient [35]. As the AER system provides support in medical decision-making, promotes the use of the guidelines, and increases the coordination between anaesthetists and other health care providers, it improves the overall anaesthesia quality of care [36]. There has been growing recognition of the role of the AER in providing quality anaesthetic care and, therefore, improvement in health outcomes [37]. This study showed the satisfaction from AER among 40% of the respondents, where 12.8 % of respondents still showed poor satisfaction. The findings of our survey are in line with a previous study of a confidential postal survey conducted for all active members of the Canadian Anesthesiologists Society [38]. Anaesthesia practice, overall job satisfaction, anaesthetic assistance, and perceived surgeons' and public attitudes towards anesthesiologists were collected. Seventy-five percent of respondents reported overall job satisfaction associated with intellectual stimulation, good quality of care, and interaction with patients. Dissatisfaction stemmed from treatment from the provincial government, hospital politics and long hours [38]. This study found that education and user support need to be reassessed by the hospital for quality checks. This study recommended proper methods to ensure user support and ongoing staff education while considering the OR's ergonomics concern.

5. Conclusion

This study compares the completeness of documentation, cost, and time analysis of handwritten anaesthesia records versus AER. The overall mean percentage compliance score of 76% and 88% was recorded for handwritten records (n=165) and AER (n=77), respectively, concluding the outperformance of the AERs over the handwritten record in the completeness of information assessment. Handwritten records proved more convenient and cost-effective than AER documents in the OR area. Compared with manual record-keeping, this study shows that AER makes end-users jobs more accessible and more accurate and provides them with greater satisfaction than previous manual methods. In addition, the study recommends a user-friendly environment with adequate training and backup to enable AER users to use the clinical information system effectively.

5.1 Limitations and Recommendations

There are limitations worth mentioning in this study.

1. The results of this study are not generalizable because health information systems differ from one health institution to another in terms of contextual discrepancies for the environment and the infrastructure within each health institute.
2. This study involved only one procedure and specific ASA types I, II, and III. The outcome could be more robust if different procedures were included.
3. For this study, the cost analysis inside the OR relied on the time analysis output. However, in future studies, different factors, such as ergonomics and environmental factors, could be looked at from the perspective of anaesthetists during documentation.
4. In this study, usual restrictions were accompanied by electronic records to ensure documentation accuracy and completeness, which is not generally possible with paper records. Hence, this raised concerns about the impact on documenting and meeting standards for AER utilisation.

6. Declarations

6.1 Conflict of Interest Statement

No conflict of interest to declare..

6.2 Funding Disclosure

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

6.3 Ethical Considerations

The study was scientifically approved by the Institutional Review Board [Ref. No: E-19-4032], Health Sciences Collages Research on Human Subjects, Research Center, Deanship of Scientific Research, KSU, Riyadh, Saudi Arabia; and by Institutional Review Board [Ref. No: C380/1017/40] at King Faisal Specialist Hospital and Research center Riyadh, Saudi Arabia and in accordance with the declaration of Helsinki for research involving human participants or human material and Human Studies**.**

6.4 Acknowledgements

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6.5 Authors contribution

AA: conceptualisation, designing of the study, drafting the article, critical revision of the article, supervision, and final approval of the version to be published. FF. A: designing the study, methodology, data collection, literature review, writing the first draft of the manuscript. SA. K: literature review, data

analysis and interpretation, drafting the results, and revision of the manuscript, journal submission and administrative support.

All authors have been involved in drafting and revising the manuscript for their intellectual content, approved the final draft, and are responsible for the content and similarity index of the manuscript.

6.6 Consent

All participants were informed about the study's aim and their consent for participation was recorded at the beginning of the study.

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