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Quality and accuracy of electronic pre-anesthesia evaluation forms

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ABSTRACT

Background and Objective: Paper-based forms have been widely used to document patient health information for anesthesia; however, hospitals are now switching to electronic patient file documentation for anesthesia. The aim of this study is to compare the quality of paper-based and electronic pre-anesthesia assessment forms.

Methods: The research conducted in this study was quasi-experimental using a pretest–posttest design without a control group. The study was conducted at King Abdulaziz Medical City, Riyadh (KAMC-RD) during November 2015. Paper-based forms were converted into electronic forms, and the paper-based pre-anesthesia forms were used during the first two weeks of the data collection period while electronic forms were completed in the last two weeks. The quality of each (electronic vs. paper) was evaluated with respect to missing items, errors, and unreadable items. The sample size included all 15 anesthetists working in the pre-anesthesia clinic at KAMC-RD. The anesthetists completed 25 pre-anesthesia forms daily during a five-day week schedule. A total of 500 patient forms were completed during the study (250 paper-based and 250 electronic forms). Anesthetists' satisfaction with the electronic pre-anesthesia form was also measured using a questionnaire.

Results: The electronic form shows significantly higher quality in all assessment categories (missing items, errors, and unreadable items; X^2 (2, N = 500) = 171.64, $p < 0.001$). The satisfaction survey found 81.65% of the anesthetists were satisfied with the electronic pre-anesthesia form for all questions.

Conclusion: Our study demonstrates that the electronic pre-anesthesia form has better data quality, meets the expectations of anesthetists and aids to decrease missing key preoperative information. This type of approach is imperative for the safety of perioperative patients.

1. Introduction

The early 1970s marked the start of pre-anesthesia assessment as a routine evaluation for surgery patients in the US using paper-based forms [1]. Pre-anesthesia evaluation is the clinical assessment that precedes the delivery of anesthesia care for surgical and non-surgical procedures. The practice advisory for pre-anesthesia evaluation by the American society of anesthesiologists demonstrates its extreme importance for anesthesia practice, enabling the hospital to minimize cancellations, improve the safety of patients, help the surgery anesthetist appropriately prepare for the procedure, and reduce operating room time loss as well as patient anxiety [2].

In the anesthesia departments of Saudi hospitals, paper-based forms are mostly used for pre-anesthesia evaluations while in the US, electronic anesthesia record systems are used [3]. Compared to electronic records, paper-based forms can be lost, damaged, or not easily accessible during anesthesia preparation , especially when the anesthetist who carried out the evaluation is different from the attending anesthetist during the surgery, which is very common [4]. Furthermore, access to paper forms in the ward may be difficult. The addition of an electronic form in the Health Information System (HIS) application may be advantageous because it can

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be accessed from any computer at any time. Farasatkish and colleagues found that the implementation of a pre-anesthesia evaluation helped reduce surgery cancellations ($p = 0.046$). Moreover, the most common cause of cancellations was found to be an incomplete medical examination (12.6%), hence confirming the importance of a pre-anesthesia evaluation [5].

The addition of an electronic pre-anesthesia record may improve the workflow, as asserted by Holzinger et al. in their evaluation study, which concluded that when a computer application was used to complete questionnaires for skin cancer patients, the completeness of forms was enhanced, its use became easy, and the time consumed to collect information was reduced by 90% compared to paper-based questionnaires that require manual entry into the electronic medical record (EMR) [6]. Other studies have explored the potential of computerized health technologies to assess care quality and user satisfaction in other departments in the healthcare system. Miller and Sim in 2004 found that quality improvements are highly dependent on the physician's use of the EMR [7]. Their study demonstrated that greater quality improvements are linked to financial benefits. In contrast, Price, Singer, and Kim focused on the data quality in EMR's in an office-based practice in Canada. Their findings indicate that electronic data quality is poor and a hassle for users [8]. In addition, Pourasghar et al. conducted a study in an Iranian hospital that had implemented an EMR system. The documentation quality of medical records was improved in areas where nurses' involvement was higher than physician involvement. The factors found to cause such results were associated with high workload, hardware shortage, and the lack of software features [9].

Although paper based forms have been used for a long time to document patient health information, hospitals all over the globe are now converting to electronic patient files. However, no research, to the best of our knowledge, has been published about pre-anesthesia electronic documentation or has explored its quality in comparison to paper based pre-anesthesia evaluation forms. This study will help other hospitals decide whether to convert from paper-based pre-anesthesia forms to electronic forms to improve quality. The aim of the study is to compare the quality of paper-based forms and electronic forms for pre-anesthesia. The study further aims to assess the satisfaction of anesthetists with the electronic pre-anesthesia form.

2. Methodology

2.1. Study design

The research is a quasi-experimental study with a pretest–posttest design without a control group. The intervention was conversion of the paper-based form into an electronic form to be used on all computers in the hospital through the hospital's Best Care Health Information System (HIS). The pre-intervention measurement was an evaluation of the paper-based form for missing items, errors, and unreadable items. The post-intervention measurement was an evaluation of the electronic form for the same variables. For each fault in these categories (missing items, errors, and unreadable items), one point was given, as shown in Table 1. The total score was calculated and then graded using a scale of A, B, or C. This design was chosen to cover the three most common problems faced in pre-anesthesia evaluation.

The second measurement was user satisfaction, which was evaluated using a survey questionnaire after the electronic form in the hospital Best Care HIS was used. This satisfaction survey was performed to evaluate the anesthetists' opinions regarding the electronic pre-anesthesia form.

2.2. Study setting

The study area was King Abdulaziz Medical City in Riyadh (KAMC-RD), the main hospital for the National Guard Health Affairs and one of the most advanced hospitals in the Kingdom of Saudi Arabia. KAMC-RD has 690 beds with an additional 132 beds for emergency cases. The Best Care HIS is only implemented in King Abdullah Specialist Children Hospital within the KAMC-RD, so all the electronic pre-anesthesia forms were gathered from there. The data was accessed through the Best Care HIS 2.0 application. For the paper-based forms, the data was taken from the King Fahad Hospital in KAMC-RD anesthesia department through the Health Information Management Department. The study was conducted in November 2015.

All English speaking anesthetists working in the pre-anesthesia clinic who were evaluating patients for pre-anesthesia were included in the study. The exclusion criteria were non-anesthetists (e.g., nurses, administration assistants, and general practitioners) working in the anesthesia department who were not allowed to perform patient pre-anesthesia evaluations.

2.3. Sample size

The sample included all 15 anesthetists working in the pre-anesthesia clinic at KAMC-RD during the study period. The anesthetists completed 25 pre-anesthesia forms daily during a five-day week schedule. A total of 500 patient forms were completed during the four weeks of the study period (250 paper-based and 250 electronic forms). The satisfaction survey was given at the end of the anesthetist rotation in the pre-anesthesia clinic because anesthetists are usually allocated to cover the anesthesia clinic for more than one day.

2.4. Sampling strategy

Random allocation using convenient sampling was used for data collection with no segregation of particular forms for particular patients. For the pre-intervention phase, paper-based pre-anesthesia forms were used for the evaluation of all patients who came to the pre-anesthesia unit during the first two weeks. The post-intervention phase consisted of a second evaluation using electronic pre-anesthesia forms to document patient data in the last two weeks of the data collection period. Although it would have been ideal to allot half of the anesthetists to the electronic condition first, followed by the paper condition, this was not a practical approach because all study participants were accustomed to paper and were using the electronic forms for the first time. The electronic form was developed by the Information Systems and Informatics Division in KAMC-RD for the Best Care HIS during the study. After the data collection was complete, these anesthetists were given a satisfaction survey to complete.

2.5. Data collection

In this section, the instruments used including two types of patient pre-anesthesia evaluation forms are reviewed and described:

2.5.1. Form review

The researchers used the following scheme to determine the number of unreadable items, errors, and missing mandatory information. Missing items were evaluated by checking whether any mandatory item fields were empty. Error was assessed by checking for incorrectly entered data that were either not in the correct field or contradicted other information in the same form. Information in a form was classed as unreadable if it could not be read by two independent evaluators.

Table 1
Evaluation criteria for paper-based and electronic pre-anesthesia forms.

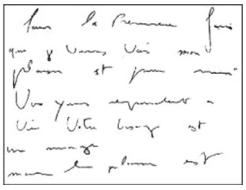
	Definition	Example
Missing items	Are mandatory items missing from the form?	A patient's age, weight, pain score, or the type of anesthesia agreed with the patient are not recorded on the form.
Error	Are the items placed in the wrong area or do they contradict other information in the same form?	Two types of anesthesia are chosen that cannot be given at the same time or a field for weight is used for date of birth.
Unreadable items	Are the items written in the form by an anesthetist but cannot be read by two reviewers?	Information is written in non-standard or unknown abbreviations like "STT" or the written text is not clear. 

Table 2
Grading scale.

Grade	Definition	Example
A	Complete paper with no faults in any quality measurement.	The completed pre-anesthesia form does not have any faults and is complete.
B	Forms with one to five faults.	A form with two missing items and one error (three faults in total).
C	Forms with six or more faults	A form with seven missing items, two errors, and three unreadable items (12 faults in total).

For each missing, erroneous, or unreadable item, one point was added by the reviewer. To classify data quality, we used an ordinal grading scale for statistical measurement, as shown in Table 2.

The data was then analyzed. The scores for each of the three variables (missing items, errors, and unreadable items) were determined for each form type. The percentage of forms within each category was also assessed. Furthermore, we calculated the fault rate for each category by dividing the number of forms in each category by the total number of faults in that category.

2.5.2. Questionnaire for satisfaction survey

This Likert scale questionnaire was developed using some pretested and validated questions from the previous literature (see the appendices for details). The questionnaire was piloted and tested for validity and reliability using Cronbach's alpha.

2.6. Ethical considerations

An Institutional Review Board approval from King Abdullah International Medical Research Center (KAIMRC) was obtained before the research was conducted.

2.7. Data analysis

The data was analyzed using IBM SPSS (Statistical Package for Social Sciences; version 22.0.0.0). Because the data is categorical and there are more than two categories, we used the chi-square test to statistically calculate significance at $p = 0.05$ for the differences in documentation quality for both form types. Descriptive statistics were used for the satisfaction survey using Likert scale as ordinal data. The independent variable was "type of record" (paper-based or electronic documentation), while the dependent variables were the quality category grading. The type of record was measured using a nominal scale while missing items, errors, unreadable items, and total faults were measured as interval scales. The grading quality was measured as an ordinal scale.

3. Results

The results are divided into three sections. The first section examines the results for the three categories: missing items, errors, and unreadable items. The second section of the analysis categorizes each form into Grades A, B, or C to determine the quality of the electronic and paper based pre-anesthesia forms. The third section discusses the results of the satisfaction survey for anesthesiologists.

3.1. Number of faults

The results for the number of faults in each category for the paper-based forms and electronic forms are given in Table 3, respectively.

There were a total of 2337 missing items, 50 errors, and 25 unreadable items found in the paper-based pre-anesthesia forms. In contrast, in the electronic pre-anesthesia forms, a total of 692 missing items, 26 errors, and 1 unreadable items points were found.

The results show that there are major differences between the paper-based and electronic pre-anesthesia forms for all fault categories. The paper-based forms had 2337 faults in 231 forms (92.4%) compared to 692 faults in only 159 forms (63.6%) in the electronic pre-anesthesia evaluations.

Table 3 compares the fault rate for electronic and paper-based pre-anesthesia forms. It clearly illustrates that the electronic forms have lower fault rates for missing items, errors, and unreadable items than the paper-based forms. The largest difference can be observed in the missing items category, which contains the majority of the faults observed in this study. The missing item fault rates were 10.11 faults per form for the paper-based forms compared to 4.35 faults per form for the electronic forms. This is clearly a significant improvement in quality caused by the use of electronic forms (a reduction of 5.76 faults per form on average).

3.2. Quality grading results

The quality grading results for the paper-based and electronic pre-anesthesia forms are shown in Table 4, respectively. There are substantial differences in the rates, specifically in the percentage of C graded forms.

Table 4 also compares the quality grading of electronic and paper-based pre-anesthesia forms. We can see that there is a much

Table 3
Fault rates in the paper-based pre-anesthesia forms and electronic pre-anesthesia forms.

	Total faults per category	Number (percentage) of forms in each fault category	Fault rate (average number of faults per form)
Paper-based pre-anesthesia forms			
Missing items	2337	231 (92.4%)	10.11
Errors	50	21 (8.4%)	2.38
Unreadable items	25	10 (4%)	2.5
Total faults	2412	231 (92.4%)	10.44
Electronic pre-anesthesia forms			
Missing items	692	159 (63.6%)	4.35
Errors	26	25 (10%)	1.04
Unreadable items	1	1 (0.4%)	1
Total faults	719	167 (66.8%)	4.30

Table 4
Quality grading results for paper based pre-anesthesia forms and electronic pre-anesthesia forms.

Quality grading	Number (percentage) of forms
Paper based pre-anesthesia	
A	19 (7.6%)
B	45 (18%)
C	186 (74.4%)
Total forms	250 (100%)
Electronic pre-anesthesia forms	
A	86 (34.4%)
B	131 (52.4%)
C	33 (13.2%)
Total forms	250 (100%)

greater percentage of both A (34.4%) and B (52.4%) quality rated electronic pre-anesthesia forms than paper-based, where the percentages of A and B quality forms were only 7.6% and 18%, respectively.

Furthermore, there was a much higher percentage (74.4%) of quality C rated paper-based forms (i.e., poor and insufficient) compared to the percentage (13.2%) of quality C rated electronic forms. The electronic forms have a significantly higher quality in all assessment categories (X^2 (2, N = 500) = 171.64, $p < 0.001$).

3.3. User satisfaction

The satisfaction survey was given to each anesthetist that completed the electronic pre-anesthesia form during the study. Fifteen out of 20 questionnaires were returned. The 15 respondents were all males and comprised nine consultants, four associate consultants, one assistant consultant, and one staff physician. Of the respondents, 46.7% had more than 20 years of experience in anesthesia, 13.3% had 15–20 years of experience, 20% had 10–15 years of experience, 13.3% had 5–10 years of experience, and 6.7% had 0–5 years of experience. Hence, more than 50% of our sample were very experienced and had used paper-based pre-anesthesia forms for a long time. In addition, question reliability measured using Cronbach's alpha was 0.695.

Fig. 1 displays the results for the satisfaction survey. The results showed a good satisfaction rate for the use of the electronic pre-anesthesia form. All participants agreed that it was easy to use the electronic device to complete the form. Additionally, 80% agreed that the electronic forms had better clarity and completeness while the other 20% responded that the paper-based and electronic forms had the same qualities with regard to clarity and completeness. Moreover, all respondents agreed or strongly agreed that the electronic evaluation allowed for better communication with the patient. However, 53.3% of the respondents were neutral about whether the electronic forms enabled them to see more patients while 20% believed it did not do so.

4. Discussion

The results of our study showed a significantly higher quality and improvement in all assessment categories for electronic forms when compared to paper based forms. Lesser fault rates for missing items, errors, and unreadable items were observed in the electronic forms. Similarly, a greater percentage of poor and insufficient quality forms were found among the paper-based forms. The satisfaction survey showed the anesthetists were overall satisfied with the use of the electronic pre-anesthesia form. Although there are many studies that compare paper-based and electronic health care documentation, there are no studies to our knowledge that can be compared with our specific study findings on pre-anesthesia evaluations.

Paper based pre-anesthesia forms have been used for more than 35 years, with some hospitals having begun electronic pre-anesthesia evaluation in the last decade. Based on our results, we can conclude that the shift from paper-based pre-anesthesia forms is highly advantageous and would improve productivity and efficiency. Likewise, many advantages with regard to the storage and access of electronic healthcare documentation have been widely reported where its use has improved the quality of documentation, ultimately helping to increase the quality of care and safety for patients by improving the legibility of the clinical notes, reducing duplication in documentation, giving access to documents anytime and anywhere, alerting healthcare providers about overdue tests, and supporting staff by adding a decision support system that can alert them if the patient is allergic to some medication or has just had a duplicate diagnostic procedure ordered for him or her [10].

Almost all participant anesthesiologists were happy with the electronic pre-anesthesia form. However, some were more satisfied with the paper-based forms. Parsons et al. [11] found that workflow and documentation habits have an impact on the quality of documentation. This impact relies on many factors, from training to the compliance of healthcare providers when completing the information correctly. The electronic form in our study used many text fields, which can reduce the possibility of using this data for a decision support system. Furthermore, the form did not have restrictions to ensure all important data were entered before the form was submitted; hence, missing data was found in the forms in our study. The errors found in the electronic pre-anesthesia forms were mainly caused by choosing two different anesthesia procedures that cannot be done at the same time; therefore, if we had designed the form to trigger an error when both types were selected simultaneously, this would have helped reduce the error rate in the electronic form.

Moreover, Vigoda et al. [12] examined the quality assurance of an anesthesia information management system in a US hospital. They measured and added an intervention to improve the quality assurance of the anesthesia report, which included education and follow up with regular reporting to improve the practice of

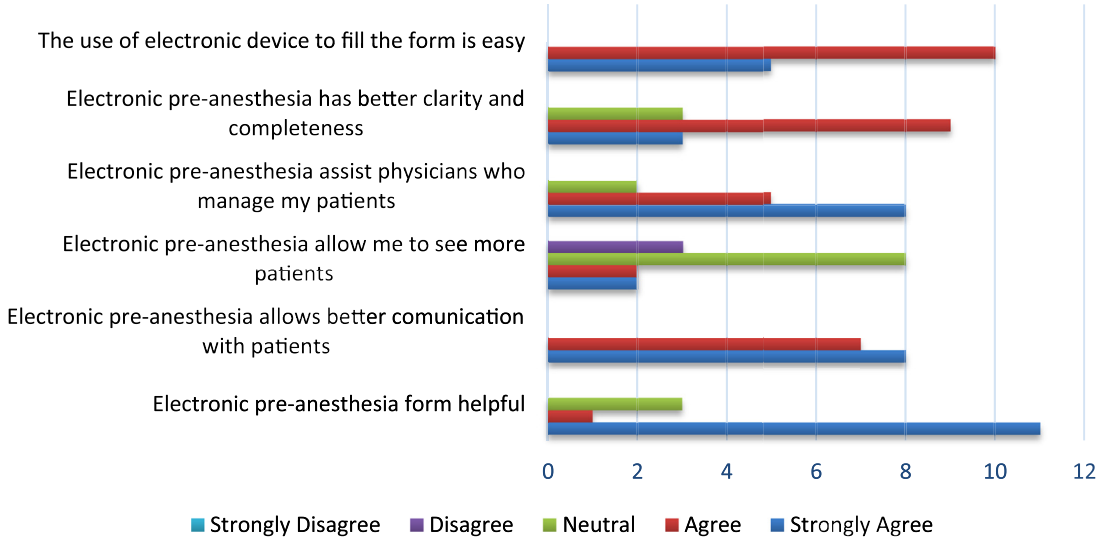


Fig. 1. Satisfaction survey results.

all staff. This method can be used to improve the quality of the electronic evaluation documentation in KAMC-RD. For physicians to make good judgments, they need high-quality patient data from multiple sources [10].

Paper-based patient documentation often lacks the ability to integrate with other forms of information. However, electronic healthcare documentation can be integrated with analytical software. Using data mining, insights about the population can be gained and the data can be used to help find optimal treatments for patients. In addition, these data can be used to perform quality reporting and discover public health issues that need to be addressed before they become worse [10]. The electronic pre-anesthesia form is far better at minimizing faults and improving the cleanliness of data; however, the forms were not currently used to their full potential in this study because the use of many text boxes in the electronic form made the data less structured. In this study, the electronic form rules could not be amended to improve the data fault rate because of time constraints. In future studies, we plan to classify each fault with a specific grade depending on the importance of that particular information and how much harm the corresponding error can cause. There are a few limitations that are worth mentioning in this study. First, the study was conducted in one location, thus applying the results to other locations should be approached carefully. Second, the study duration lasted for one month, where the electronic format of the pre-anesthesia form was deployed for two weeks. A longer period of investigation would give more insights into the impacts of this intervention. Finally, filling out the paper and electronic forms were done at the discretion of the users, where mandatory requirements would have influenced the results especially as it relates to the missing items for both the electronic and paper forms.

5. Conclusion

In this study, we compared the effectiveness and quality of a paper-based unstructured pre-anesthesia assessment form to an electronic version of the form. The use of the electronic pre-anesthesia assessment form reduced missing information and yielded better data quality as well as meeting the expectations of most anesthetists. Future research studies can help to determine the best utilization of this form to reduce the perioperative risk in different patients by facilitating the transfer of sufficient information across different care settings.

6. Authorship

All individuals who met the authorship criteria are listed as authors and all authors certify that they have participated sufficiently in the work.

7. Conflict of interest statement

There are no conflicts of interest between the authors and the study subjects.

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Appendix Satisfaction survey

Please select the number which best describes your opinion
1 Strongly disagree. **2** Disagree. **3** Neutral. **4** Agree. **5** Strongly agree
The following statements are to know your opinion regarding:

Satisfaction survey	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The use of electronic device to fill the form is easy	1	2	3	4	5
Electronic pre-anesthesia has better clarity and completeness	1	2	3	4	5
Electronic pre-anesthesia assist physicians who manage my patients	1	2	3	4	5
Electronic pre-anesthesia allow me to see more patients	1	2	3	4	5
Electronic pre-anesthesia allows better communication with patients	1	2	3	4	5
Electronic pre-anesthesia form is helpful	1	2	3	4	5

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.cmpb.2018.03.006.

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