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The Impact of Electronic Health Records Systems (EHRs) on the quality of clinical documentation

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Abstract
Background: The frequent occurrence of medical errors threatens the quality of healthcare in Saudi Arabia (KSA). Although electronic health record (EHR) systems can help to minimize such errors by improving the quality of clinical documentation, there is low EHR adoption in KSA. There is insufficient evidence available in KSA to enhance understanding of EHRs' benefits for healthcare quality. **Aim:** This study aims to provide evidence that EHR can improve healthcare quality in KSA by measuring its impact on the quality of clinical data. **Method:** This study was conducted at a Hospital in Madinah, KSA. It followed a quantitative methodology and a quasi-experimental design and depended on a sample of 578 records, which included 289 paper and 289 electronic records. Data were collected using the CRABEL (CRAwford-BEresford-Lafferty) score, a tool named after its creators, which is used to measure medical record quality in four elements of documentation: "initial clerking", "subsequent entries", "consent" and "discharge summary". The CRABEL scores overall were recorded out of 100 for both paper and electronic records to evaluate the impact of EHR. The Statistical Package for the Social Sciences (SPSS), version 25 was adopted to analysing the study's data. **Result**: The overall quality of clinical documentation improved significantly after EHR adoption from 63.94% (63.49-64.42 95% confidence interval (CI)) to 90.39% (90.11-90.65, 95% CI) (t-test P = 0.001). The differences were also detected significantly in all categories of CRABEL score between pre- and post-EHR adoption. **Conclusion:** EHRs improve clinical documentation quality and should be adopted in clinical practice.
Keywords: Electronic health record, Clinical documentation, Medical record, Healthcare quality, Paper record, Manual documentation

Introduction

Recently, technological innovations have led to significant advances in the quality of healthcare. These technologies range from the use of advanced machines for diagnosis and management to the use of computerised software for health information management **(1).**

Electronic health records (EHRs) are one such technology and have proven efficient and effective in providing high-quality healthcare**.** EHRs follow a digital system that collects, controls and stores patient information electronically. These advantages are reflected in the improvement of clinical documentation quality, that enhance quality and safety of healthcare provide to patients **(2).**

Clinical documentation quality is a key indicator of healthcare quality, as clinical documentation contains all patients' information that is input by healthcare providers, such as clinicians, including reports, diagnoses and medication lists (**3).**

The implementation of EHRs affords healthcare providers an opportunity to improve clinical data quality and ease of use for sustained continuity of care, unlike paper documentation, which is difficult to manage; data quality refers to the level to which data is fit for purpose in terms of improving healthcare quality **(4).**

Overall, EHRs can improve the accuracy, completeness, legibility and integrity of documentation—properties that constitute the main concerns of paper-based medical However, EHRs also can negatively affect the quality of clinical documentation if used inadequately or inappropriately. Nonetheless, EHRs generally have a positive impact in terms of mitigating medical errors and enhancing clinical data. Medical errors most frequently occur as a result of poor clinical documentation quality, which threatens patient safety **(5).**

As noted above, EHRs can help to improve data quality, thereby reducing the incidence of medical errors, but the rate of EHR adoption in the KSA is low, which may negatively affect healthcare quality. For example, a study by **Al-Aswad (2015)** conducted in eastern KSA found that only three MOH hospitals out of 29 implemented EHRs. Moreover, in KSA's capital, Riyadh, **Aldosari (2017)** reported that only11 out of 22 MOH hospitals had implemented EHRs**. (6).**

It is crucial to ensure that hospitals in the KSA adopt data-enhancing EHRs in the interest of minimising the occurrence of medical errors. This can be achieved by utilising studies that have established the relationship between EHRs and clinical documentation quality as a means of convincing healthcare providers to adopt EHRs. Thus, using one Saudi MOH hospital as a sample location and applying CRABEL scoring, the following research question guided this study: "has the implementation of EHR improved the quality of clinical documentation at Hospital of Madinah City in the KSA, based on the CRABEL score"?

This study aims to highlight the positive impacts of EHRs on the quality of clinical data in KSA, to encourage EHR adoption and thus minimise the occurrence of medical errors in Saudi hospitals.

Methods

The present study was carried in the large MOH general hospital in Madinah, KSA, with full EHR implementation. Madinah is large city in northern KSA. The Hospital has many departments, including vascular, general care and urology. It offers both outpatient and inpatient services. The context of this study was the inpatients' medical records.

Study Population:

A quantitative methodology and a quasi-experimental design were adopted in this study. Quantitative methods collect numerical data that allows the researcher to

perform various statistical analyses. This methodology also focuses on a large number of samples, meaning that the phenomenon under investigation can be described statistically and accurately. Another advantage is that a quantitative methodology helps to highlight the existing relationships between variables so that predictions can be made. However, a quantitative methodology uses structured tools to collect data, which reduces the likelihood that in-depth information will be obtained **(7).**

Nevertheless, a quantitative methodology remains reliable because its application of inferential statistics increases the likelihood that the findings will be inferred to the target population. Additionally, a quantitative methodology emphasises the objectivity of the collected and analysed data **(7).** In using a quantitative method, it was easier to test the influence of EHRs on documentation quality objectively, and therefore easier to convince the target audience of the need to adopt EHRs.

The current study was carried out six months before and six months after the adoption of EHR at Hospital. A one-year duration was deemed appropriate because time was required to establish the cause-effect relationship of EHR implementation **(8).**

Inclusion and exclusion criteria:

Inpatients' paper-based medical records from January to June 2018 were included, while electronic records from January to June 2019 were included. The exclusion criteria were medical records from July to December 2018, because this was the period during which the EHR system was being implemented and healthcare workers were being trained in its use. This exclusion alleviated the threat of possible errors in documentation, which was likely to occur while the healthcare providers were undergoing training in EHR **(9).**

Sample size

The study sample size concerns the participants that are selected from the study population. To choose the appropriate sample, the study's purpose and target population size must be considered, along with the risks associated with poor sample selection and sampling errors. The current study's population comprised of 1,160 inpatients' medical records. Thus, the outcomes from a representative sample are unbiased and can be generalised to a target population, thus enhancing the applicability of the research in clinical practice **(10).**

The sample size comprised 289 medical records based on a power calculator, used as a tool to determine and therefore control the sample size, based on the desired confidence level. The calculation of this sample size involved a sampling error of 0.05 because it was calculated at a 95% CI (Appendix A). Therefore, the sample consisted of 289 paper medical records before EHR implementation and 289 electronic medical records after EHR implementation, leading to an overall sample size of 578 medical records.

Data collection

CRABEL scoring was applied to the data collected, which focuses on four components of documentation: "initial clerking, subsequent entries, consent and discharge summary". CRABEL scoring was introduced in 2001 and named for its authors; it is not intended to be an indicator of medical note quality in terms of content, nor does it evaluate whether the patient management process is appropriate The purpose of the CRABEL score is to evaluate the quality of medical record keeping in hospitals **(11).**

CRABEL scoring is a valid and reliable audit tool for data collection, having often been used to evaluate the level of clinical data quality in medical records

Figure 1: The CRABEL score marking method (Suh et al., 2009).

*Where '/' is present, omitting either incurs deduction of 1 point

Initial Clerking (10 points total)

1. Patient name (at top of sheet)
2. Patient Hospital number
3. Referral source (GP, A&E etc)
4. Name of Admitting Consultant
5. Date/ time *
6. Working Diagnosis (or differential diagnosis)
7. Management Plan
8. Result of Investigations
9. Signature
10. Name/ Post/ Bleep no.*

Subsequent Entries (30 points total, up to 5 entries)

1. Patient Name/ Number*
2. Date/ time*
3. Heading (Ward Round & name of leader- consultant or registrar)
4. Results of investigations
5. Legibility (1 point deducted for any entry with ≥2 illegible words)
6. Signature/ Name/ Post/ Bleep no.*

Consent (5 points total)

1. Patient name
2. Hospital number
3. Operation in full without abbreviation
4. Risk/ complication
5. Signatures (clinicians/ guardians)

Discharge Summary (5 points total)

1. Patient details
2. Admission/ discharge dates*
3. Diagnosis/ management*
4. Medication
5. Follow-up plans

Total deductions [ ] + [ ] + [ ] + [ ] − [ ]

CRABEL SCORE (50 − deductions) x 2 − [ ]%

Data analysis

The statistical software adopted to analysing the study's data was the Statistical Package for the Social Sciences (SPSS), version 25, because it is not only popular but is also powerful in manipulating quantitative data and yielding quality results with clear visual representations that are easy to interpret.

Ethical considerations

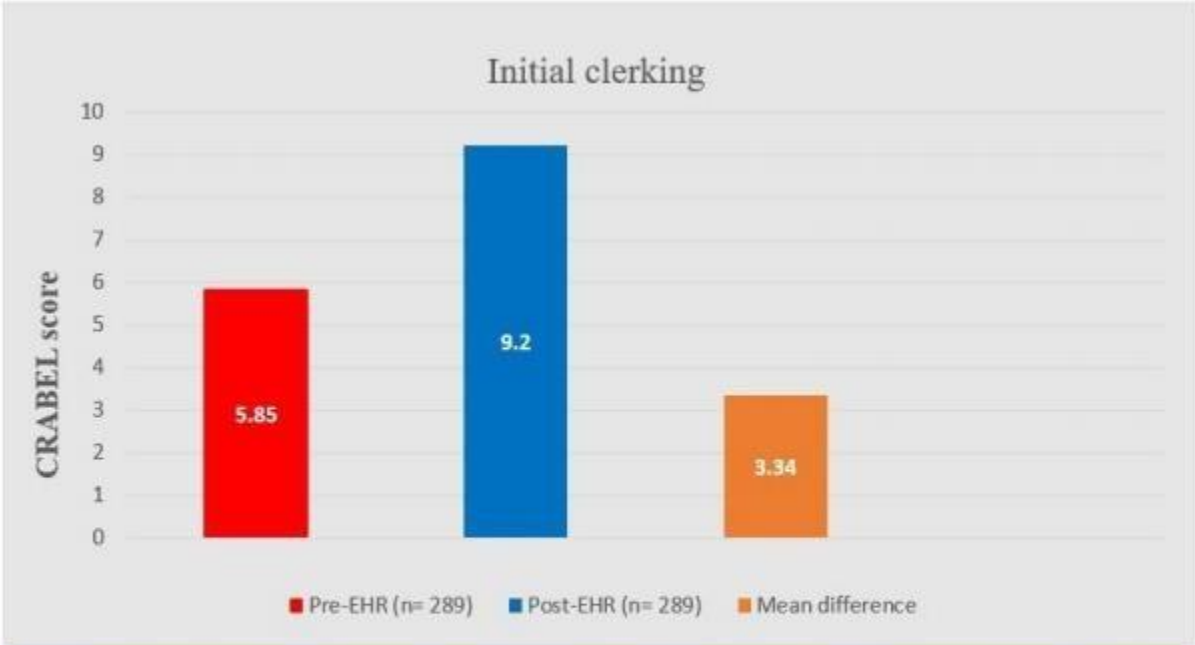
Ethical approval is an indication that the study will comply with the ethical principles that protect the research participants (Mascalzoni et al., 2015; Porsdam et al., 2016). Therefore, the ethical approval required to conduct this research was obtained from Swansea University and the Institutional Review Board of the MOH in KSA. These ethical approvals accepted to review of medical records (both paper and electronic) at Hospital. Confidentiality and privacy were maintained based on patients' rights and healthcare policies aimed at preventing any breaches of patients' information

Results

1. **Initial clerking**

The category of initial clerking indicated a significant statistical difference between paper and electronic medical records scores, as probability value = 0.001 < 0.05, with the notable improvement of mean CRABEL score from 11.63 out of 20 pre-EHR to 17.47 out of 20 post- EHR **(Figure 1).**

Figure 1: The mean CRABEL scores of initial clerking both pre- and post-HER implementation.

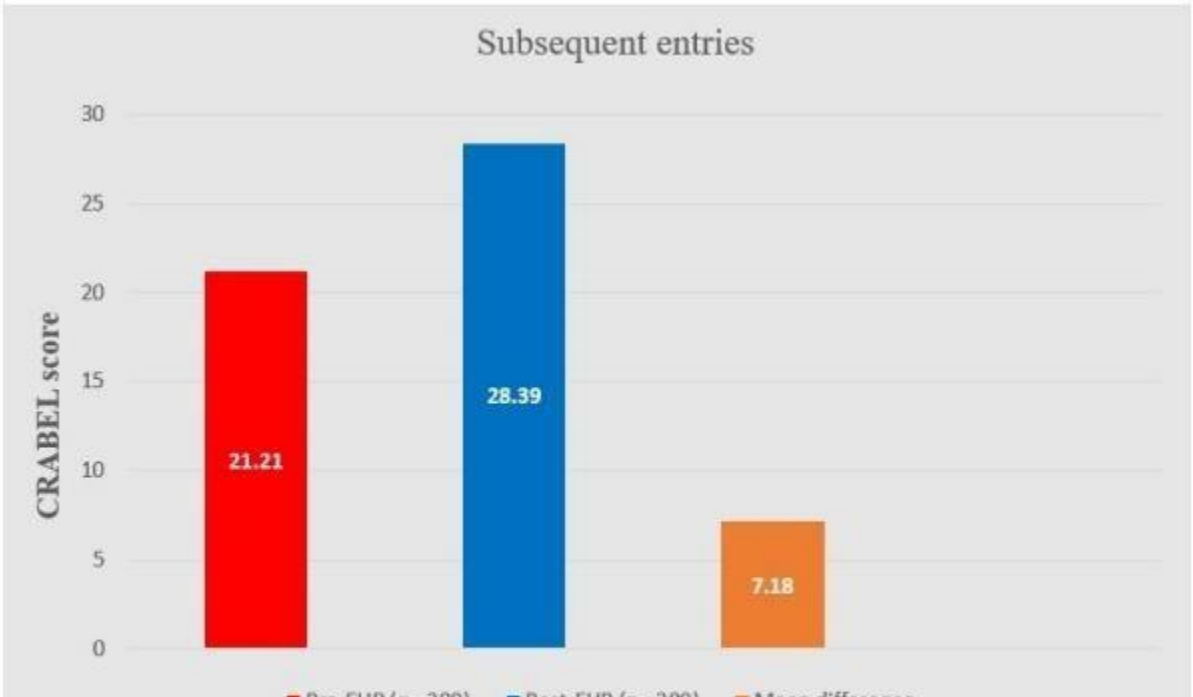


CRABEL category	EHR	Mean CRABEL score (95% C.I)	Mean difference	P-value
Initial clerking	Pre-EHR	5.85 (5.79–5.92)	3.34	0.001
	Post-EHR	9.20 (9.6–6.34)		

2. Subsequent entries

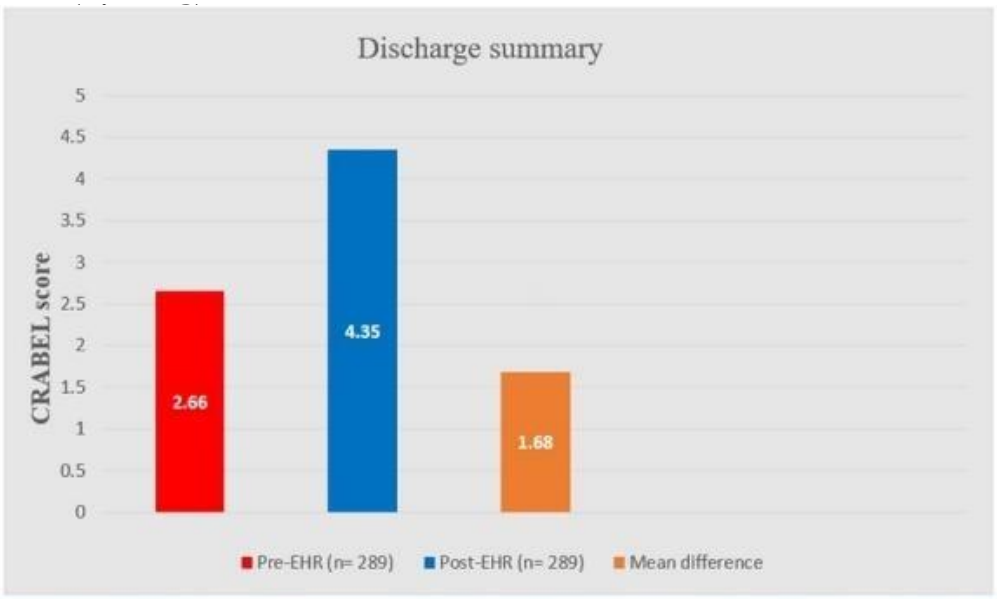
Similar to initial clerking, the subsequent entries category showed a significant statistical difference between paper and electronic medical records scores (P-value = 0.001 < 0.05), with the significant improvement of mean CRABEL score from 38.69 to 57.27 out of 60 post-EHR **(Figure 2).**

Figure 2: The mean CRABEL scores of subsequent entries pre- and post-HER implementation.



3. Discharge summary

The fourth category is discharge summary, which indicated a significant statistical difference between paper and electronic medical records scores (P-value = 0.001 < 0.05), with the improvement of mean CRABEL score from 2.66 to 4.35 out of 5 post-

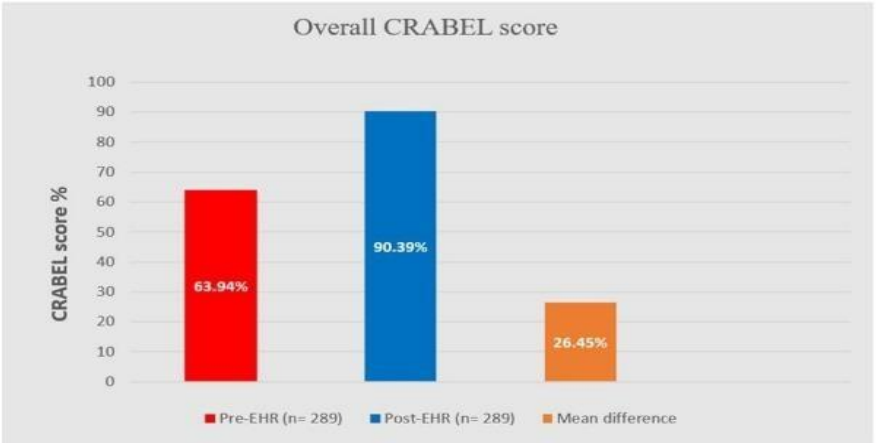


CRABEL category	EHR	Mean CRABEL score (95% C.I)	Mean difference	P-value
Discharge summary	Pre-EHR	2.66 (2.47–2.63)	1.68	0.001
	Post-EHR	4.35 (4.29–4.40)		

4. Overall quality of clinical documentation

Finally, the overall CRABEL score exhibited a significant statistical difference between paper and electronic medical records (P-value = 0.001 < 0.05). Therefore, EHR improved the quality of clinical documentation significantly in comparison with the paper system, from 63.94% to 90.39% **(Figure 4).**

Figure 4: Comparison of overall CRABEL scores pre- and post-EHR implementation.



CRABEL category	EHR	Mean CRABEL score (95% C.I)	Mean difference	P-value
Overall CRABEL score	Pre-EHR	63.94% (63.49–64.42)	26.45%	0.001
	Post-EHR	90.39% (90.11–90.65)		

DISCUSSION

This study has found a clear association between the EHR system and improved clinical documentation quality. Thus, the quality of medical records in all four categories of CRABEL score were improved significantly after the implementation of EHR. The mean overall documentation quality post-EHR implementation improved significantly from %63.94to 90.39%. Possible reasons for these findings are the effective functionalities of EHRs, such as data management, notifications, communications and security and accessibility of information. EHR systems have helped to improve the performance of healthcare providers and ensure that they have access to all the information required to deliver appropriate patient care in a collaborative environment **(12).**

Similar studies to the present study established that the quality of electronic medical records is usually higher than that of paper documentation. For example, **Jamieson et al. (2016)** found that, at an academic hospital in Toronto, EHR improved quality of clinical notes in comparison with the paper-based system from 69% to 90% respectively. In addition, in a study from the US, **Burke et al. (2014),** asserted that EHR implementation improved inpatient notes quality from 64.4% to 83.7% respectively. **(13).**

This study focused on three main elements of data quality: legibility, completeness and integrity. Specifically, in the subsequent entries, the mean CRABEL score improved significantly from 38.69 to 57.27 out of 60 post-EHR implementation. First, one of the main advantages of EHR is that it improves documentation legibility through its use of typed information rather than handwritten and is integration with advanced documentation systems that enhance the clinical data legibility. Indeed, **Brits et al. (2017),** in a study targeting clinicians from the National District Hospital in Bloemfontein, South Africa, found that in the hospital's paper-based system, the pharmacy department was unable to identify most of the medication names, due to illegibility **(14).**

The third element is documentation integrity, which involves patient identification, author validation and amendments to medical records. Integrity of documentation is critical in preventing negative effects on patient data quality. EHRs can improve documentation integrity by maintaining and controlling documentation activities **(Bowman, 2013; Wiebe et al. 2018). Amroze et al. (2019) and Vimalachandran et al. (2016**) observed that EHRs improve documentation integrity in medical records due to their effective security functionality, which can control and track any changes in medical records that may cause integrity issues, thus improving healthcare quality and safety **(5).**

Although consent in this study showed statistically significant improvement after HER implementation, the mean score slightly improved from 2.55 to 3.55 out of 5. This indicates that the mean CRABEL score difference between consent in paper records and consent after implementation EHR was only one score. It may be that certain aspects of consent documentation, such as operation in full and complications were inappropriately documented by a healthcare provider in this study. One possible reason for this may be the insufficiency of EHR documentation tools, such as templates, this depends on the templates' design, as some have limited options with regard to inputting patient information. This could diminish documentation quality or, moreover, lead to a negative impact on documentation quality. Although the present study detected no negative impact of EHR on data quality, there persists the perception that EHRs may fail to make any improvements. This perception is

associated with EHR implementation, as they depend on efficient documentation tools **(15).**

Limitations

Limitations are common in medical studies. One of the present study's limitations was that the instrument used for data collection did not capture other variables that could have influenced documentation quality, such as increased workload among healthcare providers and patients' general conditions. This compromises the study's findings because the above variables were not controlled **(16).**

In conclusion, Regarding the research question, it is evident that EHR is associated with the improvement of clinical documentation quality, in comparison with paper-based systems. The improvement in quality was identified in the main elements of documentation quality, namely legibility, completeness and integrity. EHRs play a significant role in information management and improvement. This study reports that the overall quality of clinical documentation improved from 63.94% to 90.39 %, following the implementation of EHR. Previous studies have reported similar findings to this study, that a positive association exists between EHR and the improvement of clinical documentation quality. It can be declared that the current study's findings are reliable.

However, analysis of an EHR system's implementation has demonstrated that it may not be easy to convince stakeholders of its practical value (Tilahun & Fritz, 2015; Al-Aswad, 2015). Thus, it is essential to clearly outline for stakeholders the benefits of EHRs in terms of healthcare quality. This study provides evidence for stakeholders about the benefits of EHRs in improving clinical documentation, which, in turn, is positively reflected in the enhanced safety and quality of healthcare. This may help to highlight the role of EHRs in supporting

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