Meta-Analysis: The Effectiveness of Electronic Medical Record (EMR) on the Quality of Health Services

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ABSTRACT

Background: Electronic Medical Record (EMR) is designed to improve communication between healthcare providers within and between organizations by automating the collection, use, and storage of patient information. This study aims to determine the effectiveness of Electronic Medical Records (EMR) in supporting existing health services in health service facilities.

Subjects and Method: This study is a meta-analysis and systematic review study, with PICO Population= Hospitals that use an EMR system. Intervention= Electronic Medical Record. Comparison= Without Electronic Medical Record (EMR). Outcome= Quality of health services. The articles used in this research were obtained from several databases including PubMed, ScienceDirect, and Google Scholar. Keywords to find articles are: "EMR" OR "effectiveness of EMR use" OR "health care quality" OR "EMR effectiveness". The articles used are full-text articles in English from 2009 to 2021. Articles were selected using the PRISMA flow diagram. Articles were analyzed using the RevMan 5.3 application.

Results: A total of 10 articles reviewed in this meta-analysis study were from America, Saudi Arabia, London, and Taipei. Studies show that the use of EMR improves the quality of health care (aOR= 1.13 (95% CI= 1.01 – 1.26).

Conclusion: Health services that use electronic medical records are 1.13 times more effective in improving health services compared to conventional medical records.

Keywords: quality of health services, electronic medical records

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BACKGROUND

Electronic medical records (RME) are designed to improve communication between providers within and between organizations by automating the collection, use, and storage of patient information. Additionally, EMRs can facilitate guideline compliance and decision support (Gibson, 2021). Many single-site studies in academic hospitals provide evidence that specific

EMR functions, such as clinical decision support or computerized physician order entry, can improve quality by reducing errors (Chaudhry, 2016).

Other studies using large samples of hospitals have found evidence that overall spending on health information technology (IT) is associated with improved patient safety, higher quality of care, and reduced costs. The Institute of Medicine (IOM) has encouraged the adoption of EMRs to reduce medical errors, and the American Recovery and Reinvestment Act (ARRA) of 2009 established financial incentives for hospitals to promote the adoption and meaningful use of health IT. Despite efforts to encourage EMR adoption, the impact of EMRs on outcomes in US hospitals remains unknown.

Specifically, the effects of EMR on 30-day readmission, 30-day mortality, inpatient mortality, and length of stay have not been well characterized in community hospitals. EMR influences hospital care outcomes can help policymakers promote their effective use. This study examined the association between basic EMR adoption and 30-day readmission, 30-day mortality, inpatient mortality, and length of stay at 708 acute care hospitals in the US. We used Healthcare Information and Management Systems Society (HIMSS) data aggregated to 5% of Medicare data from 2000 to 2007.

SUBJECTS AND METHOD

1. Study Design
The study design used in this research is a systematic study and meta-analysis. The articles were obtained from the PubMed, ScienceDirect, and Google Scholar databases. The keywords used to search for articles were "EMR" OR "effectiveness of using EMR" OR "quality of health care" OR "effectiveness of EMR".

2. Steps of Meta-Analysis
Meta-analysis analysis was carried out through 5 steps as follows:
1) Formulate research questions using the PICO model (Population = Hospitals that use an EMR system. Intervention = Electronic Medical Record (EMR). Comparison= Without Electronic Medical Record (EMR). Outcome= Quality of health services).
2) Search for research articles from online databases, namely PubMed, Science Direct, and Google Scholar.
3) Conduct screening and assess the quality of the research articles obtained.
4) Extract and analyze data into RevMan 5.3 software.
5) Interpret the results and draw conclusions.

3. Inclusion Criteria
The articles included in this study were complete paper articles with a cohort study design. The research subjects were hospitals that used an EMR system. Selected articles discussed EMR resulting improvements in health care.

4. Exclusion Criteria
The articles used in this research are articles with a cohort study design, articles that are not full-text, and articles that are not published in English.

5. Operational Definition
Electronic Medical Record (EMR) are programs created to manage patient documentation in health services. All actions, therapy programs, patient identity and so on that are related to the patient when using health services are included in the documentation aspect which is then archived in digital/electronic form

Quality of Health Services s one of the quality indicators that all health service providers must pay attention to. The quality of health services can describe the effectiveness of services provided by service

providers to service users to improve the health status of the community.

6. Study Instrument

The This research used the PRISMA diagram and evaluated the articles using the Critical Appraisal Cohort

7. Data Analysis

ata processing was carried out using Review Manager (RevMan 5.3) by entering the Adjusted odd ratio (aOR) value to determine the combined study model and form the final meta-analysis results. Forest plots and funnel plots were used to determine the size of the relationship and heterogeneity of research data.

The article search process was carried out through several journal databases including Google Scholar, PubMed, and Science Direct. The review process for related articles can be seen in the PRISMA flowchart in Figure 1. Research related to the effectiveness of using EMR in health services totaled 10 articles. The initial search process produced 769 articles, after the deletion process 739 articles were obtained, 25 of which met the requirements for further full text review. Furthermore, 10 articles that met the quality assessment were included in the quantitative synthesis meta-analysis. This study article originated from 5 countries, namely London, America, Taipei, Texas and Saudi Arabia.
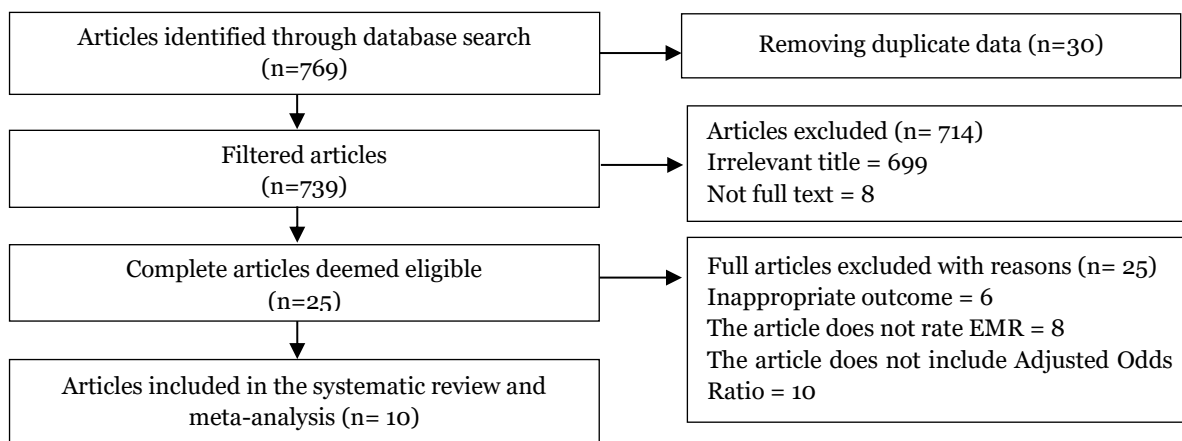

Figure 1. PRISMA Flow diagram

Figure 2. Map of the distribution of research on the effectiveness of electronic medical record (EMR) on the quality of health services

Figure 2 shows a map of the distribution of research on the effectiveness of electronic medical record (EMR) on the quality of health services. Based on 10 research articles obtained from 3 continents, 5 study was obtained from the Americas. 2 studies were obtained from the European continent. 3 studies were obtained from the Asian .

Table 1. Critical appraisal checklist for cohort study

Primary Study	Question Criteria														Total
	1				2		3		4		5	6		7	
	a	b	c	d	a	b	a	b	a	b		a	b		
Lee *et al.* (2013)	2	2	2	2	2	2	2	2	2	2	2	2	2	1	27
Al Dorzi *et al.* (2011)	2	2	2	2	2	2	2	2	2	2	2	2	2	1	27
Collin et al., (2008)	2	2	2	2	2	2	2	1	2	2	2	2	2	1	26
Murphy (2014)	2	2	2	2	2	2	2	2	2	2	2	2	2	1	27
Lin et al., (2020)	2	2	2	2	2	2	2	2	2	2	2	2	2	1	27
(Price-Haywood et al., 2021)	2	2	2	2	2	2	2	2	2	2	2	2	2	1	27
Amarasingham et al., (2009)	2	2	2	2	2	2	2	2	2	2	2	2	2	1	27
Teufel et al., (2012)	2	2	2	2	2	2	2	2	2	2	2	2	2	1	27
Filice et al., (2013)	2	2	2	2	2	2	2	2	2	2	2	2	2	1	27
Holdsworth et al., (2015)	2	2	2	2	2	2	2	2	2	2	2	2	2	1	27

Description of the answer score:

1 = Yes

0 = No

Question criteria descriptions:

1. Formulation of research questions in the acronym PICO
a. Is Is the population in the primary study the same as the population in the PICO meta-analysis?
b. Is the operational definition of intervention, namely exposed status in the primary study, the same as the definition intended in the meta-analysis?
c. Is the comparison, namely the unexposed status used by the primary study, the same as the definition intended in the meta-analysis
d. Are the outcome variables examined in the primary studies the same as the definition intended in the meta analysis?
2. Methods for selecting research subjects
a. Does the target population and accessible population not experience the outcomes studied at the start of the study?
b. Is there a distinction between the exposed group and the unexposed group and the unexposed group at the start of the study?

3. Methods for measuring exposure (intervention) and outcome variables
a. Are exposure and outcome variables measured with the same instruments in all primary studies?
b. If the variable is measured on a categorical scale, are the cutoffs or categories used the same across primary studies?
4. Design-related bias
a. Is there no possibility of "Loss-to Follow-up Bias" in primary studies?
b. Have primary study researchers made efforts to prevent or overcome such bias (for example, selecting highly motivated subjects, subjects who are easy to follow, or providing incentives to subjects so they do not drop out)
5. Methods for controlling confounding
a. Have primary study researchers made efforts to control the influence of confounding? (for example, carrying out multivariate analysis to control the influence of a number of confounding factors, or do the matching)
6. Statistical analysis methods

Does the researcher analyze the data in this primary study using a multivariate analysis model? (e.g., multiple linear regression analysis, multiple logistic regression analysis, Cox regression analysis)

7. Conflict of interest
Is there no possibility of a conflict of interest with the research sponsor, which could cause bias in concluding the research results?

Table 2. Table PICO Summary of the main study article with a cohort design on the Effectiveness of Electronic Medical Records (EMR) on the Quality of Health Services

Author	Country	Sample	P	I	C	O
Collin et al. (2018)	London	4	Data patients recorded in EMR	CPOE and PACS	Conventional medical record	Quality of health services
Murphy et al. (2014)	United States	1	Data patients recorded in EMR	EHR	Conventional medical record	Quality of health services
Lin et al. (2017)	Taipei	3	Data patients recorded in EMR	EMR	Conventional medical record	Quality of health services
Lee et al., (2017)	Texas	425	Data patients recorded in EMR	EMR	Conventional medical record	Quality of health services
Al-Dorziet al., (2018)	Saudi Arabia	1	Data patients recorded in EMR	CPOE	Conventional medical record	Quality of health services
Haywood et al. (2020)	London	36	Data patients recorded in EMR	EMR	Conventional medical record	Quality of health services
Amaring-sham et al. (2009).	United States	1	Patients using CIT	CIT	Conventional medical record	Quality of health services
Teufel et al. (2011).)	Taipei	3	Patients using CPOE	CPOE	Conventional medical record	Quality of health services
Filice et al. (2013)	United States	1	Patients using CDSS	CDSS	Conventional medical record	Quality of health services
Holdswort	United States	1	Patients using CPOE	CPOE	Conventional medical record	Quality of health services

Table 3. Data on adjusted odds ratio (aOR) and 95% confidence interval (CI 95%) on the Effectiveness of Electronic Medical Records (EMR) on the Quality of Health Services

Author (Year)	aOR	CI 95%	
		Lower limit	Upper limit
Lee et al. (2013)	0.98	0.87	1.10
Al Dorzi et al. (2011)	0.96	0.70	1.32
Collin et al. (2008)	0.98	0.89	1.08
Murphy (2014)	0.96	0.88	1.05
Lin et al. (2020)	1.67	1.13	2.47
Price-Haywood et al. (2021)	1.87	1.22	2.87
Amarasingham et al. (2009)	1.15	0.89	1.49
Teufel et al. (2012)	1.25	0.98	1.59
Filice et al. (2013)	1.83	1.13	2.96
Holdsworth et al. (2015)	1.21	0.97	1.51

Table 2 presents a summary of the source articles obtained by 10 primary articles with a cohort study design used for meta-analysis on the Effectiveness of Electronic Medical Records (EMR) on the Quality of Health
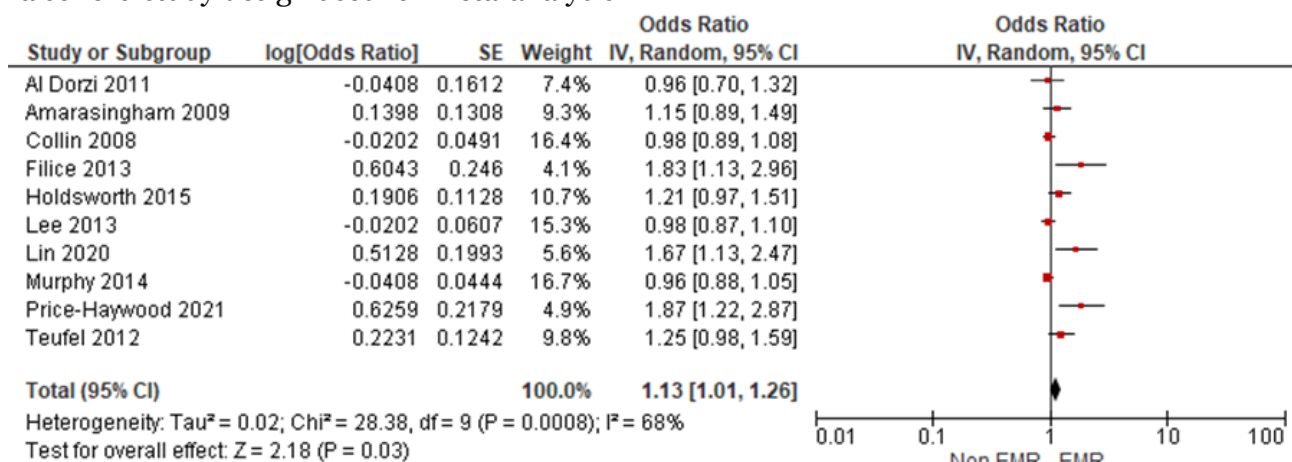
Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Al Dorzi 2011	-0.0408	0.1612	7.4%	0.96 [0.70, 1.32]
Amarasingham 2009	0.1398	0.1308	9.3%	1.15 [0.89, 1.49]
Collin 2008	-0.0202	0.0491	16.4%	0.98 [0.89, 1.08]
Filice 2013	0.6043	0.246	4.1%	1.83 [1.13, 2.96]
Holdsworth 2015	0.1906	0.1128	10.7%	1.21 [0.97, 1.51]
Lee 2013	-0.0202	0.0607	15.3%	0.98 [0.87, 1.10]
Lin 2020	0.5128	0.1993	5.6%	1.67 [1.13, 2.47]
Murphy 2014	-0.0408	0.0444	16.7%	0.96 [0.88, 1.05]
Price-Haywood 2021	0.6259	0.2179	4.9%	1.87 [1.22, 2.87]
Teufel 2012	0.2231	0.1242	9.8%	1.25 [0.98, 1.59]
Total (95% CI)			100.0%	1.13 [1.01, 1.26]

Heterogeneity: Tau² = 0.02; Chi² = 28.38, df = 9 (P = 0.0008); I² = 68%
Test for overall effect: Z = 2.18 (P = 0.03)

Figure 3. Forest plot of the Effectiveness of Electronic Medical Records (EMR) on the Quality of Health

a. Forest plot

The forest plot (Figure 2) shows that there was a relationship between the use of Electronic Medical Records (EMR) on the quality of health services (OR= 1.13; 95% CI= 1.13 to 1.26; p= 0.030). Heterogeneity of research data showed that I^2= 68% so that the data distribution was declared heterogeneous (random effect model).
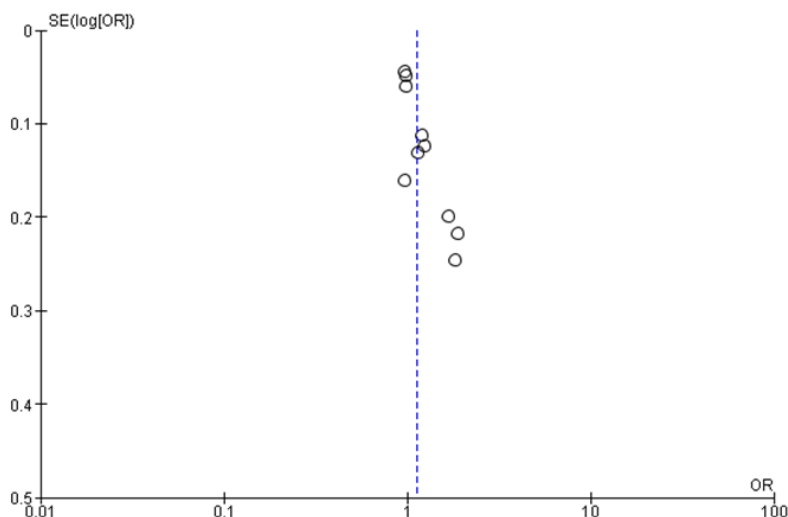

Figure 4. Funnel plot of the Effectiveness of Electronic Medical Records (EMR) on the Quality of Health Services

b. Funnel plot

The shape of the funnel plot showed that there was potential for publication bias which was characterized by an overestimate effect which was characterized by an asymmetrical distribution between plots (4 plots on the left, 5 plots on the right and 2 plots touch the vertical line, 1 plot is in the middle of the vertical).

DISCUSSION

The era of digitalization has caused many sectors to experience the impact of change. The health sector is one of the areas affected by the digitalization era. The development of information technology also has an impact on the health sector. One of the impacts in the health sector is the existence of electronic medical records. Many health agencies use electronic medical records in the documentation system for the health services provided. However, some health agencies still do not utilize the electronic medical records.

The development of electronic medical records has created pros and cons in health services, because providing health services must adapt to new systems. This study was conducted to increase the generalization of findings and obtain convincing conclusions from various similar research results. The use of Electronic Medical Records (EMR) can improve health services by 1.13 times compared to without using EMR. Good quality health services will have an impact on the perception of patient satisfaction which can help efforts in improving patient health from a psychological perspective (Kurniawan et al., 2023). Research conducted by Lee (2013) on the effectiveness of electronic medical records (EMR) on the quality of health services obtained The results show that EMR has an influence on the health services provided, so that services are more effective. This is considered important because currently almost all health services use EMR with different names in each health service agency (Chaudhry, 2016).

The number of relevant and easily accessible studies published is still low and has data access problems (data duplication). The results of systematic studies and meta-analysis are presented in the form of Forest plots and Funnel plots. The forest plot provides an overview of each study included in the meta-analysis and shows the overall results. The forest plot shows the amount of variation (heterogeneity) between study results visually (Murti, 2018).

A systematic review and meta-analysis in a study done by Lee (2013) which found that hospitals that adopted EMR experienced 0.11 (95% CI: -0.218 to −0.002) days shorter than length of stay and 0.182 percent lower 30-day mortality, but a 0.19 (95% CI= 0.001 to 0.003) percent increase in 30-day hospitalizations in the two years after EMR adoption. Associations of EMR adoption with outcomes also varied by admission type (medical vs. surgical). This also improves health services.

This study is in line with Al-Dorzi et al. (2011) regarding the use of CPOE which resulted in (aOR) 0.96, 95% confidence interval [CI] 0.70-1.32) on shortened length of stay and death in hospital (aOR 1.00, 95% CI 0.8-1.3). There was no increase in mortality after CPOE implementation.

Holdworsht (2016) showed that a computerized physician order entry system with substantive decision support was associated with a reduction in adverse drug events, length of stay and length of patient waiting process and potential adverse events in the inpatient population. The development of a service system that uses EMR can help medical personnel carry out centralized documentation.

A study by Latipah et al. (2021) found that the use of EMR was proven to be effective in improving the quality of health services. EMR can help doctors and nurses in documenting the actions and therapy programs that patients need, so that confirming the diagnosis and providing therapy can be efficient and effective.

Good health services will have a positive impact on patients, therefore, patients will be loyal and have a good perception of the

service agency. A study conducted by Danarahmanto et al. (2021) found that the implementation of EMR in health service facilities had an effect on patient loyalty because patients felt satisfied with the services provided by health workers.

AUTHOR CONTRIBUTION

Hendra Dwi Kurniawan is the main researcher who chose the topic, explored and collected research data. Aris Widiyanto, Santy Irene Putri and Retno Dewi Prisusanti have a role in analyzing data and reviewing study documents

CONFLICT OF INTEREST

There was no conflict of interest in the study.

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