Value of the Electronic Medical Record for Hospital Care: A Review of the Literature

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ABSTRACT
Electronic medical records (EMRs) are a core means to reduce hospital costs and to improve quality of hospital care. In this work, empirical studies between 2004 and 2010 were analyzed to summarize the evidence of economic and medical benefits achieved. Using Medline, 578 articles were retrieved with seven studies compliant with the inclusion criteria. Five studies supported a reduction of costs; another study found a negative effect. Relating to health care quality, five studies gave at least positive indices, while another found mixed results. The small number of relevant studies might be due to a shift from hospital care to outpatient and ambulatory care. In view of the good evidence from local implementations, the pervasion of EMRs is surprisingly low. This corresponds with intermingled results based on analyses of secondary data from large samples of hospitals. More public awareness is needed to convince health care providers to implement EMRs.

Keywords: benefits and costs; hospitals; medical record system, computerized; quality of health care; technology assessment, biomedical.

1. INTRODUCTION
An electronic medical record (EMR) has the potential to improve administrative processes, to overcome problems of paper-based documentation, to assure quality of treatment, to automate input requirements, and to improve quality control. However, an overall economic assessment from a national point of view was missing in our 2008 review [1]. Particularly, the existing studies did not provide a clear answer whether or not the use of EMRs improves quality of care. The objective of this review update is to summarize the current evidence regarding benefits and costs of an EMR in hospital care.

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The Department of Veterans Affairs supports the notion of administrative benefits [2]. Fletcher et al. summarized 35 years of experiences with EMRs and list several advantages such as improving hospital efficiency, enabling physicians to access patient information more easily, enabling new opportunities for patient education, and giving healthcare providers more time for their patients. DesRoches et al. [3] indicated improvements by EMR use on several aspects of quality of care: clinical decisions, communication with other providers and with patients, timely access to medical records, avoiding medication errors, delivery of both preventive and chronic illness care that meet corresponding guidelines, etc.

Despite the recognized benefits, the adoption of EMR in hospitals has been slow. Jha et al. [4] carried out a survey between March and September, 2008, including 3049 of 4832 US hospitals. Less than 2% had a comprehensive EMR, and - depending on the definition used - only between 8% and 12% of the hospitals had a basic EMR. More than 90% of US hospitals do not even meet the requirements of a basic EMR, if one demands the presence of functionalities for physicians' notes and nursing assessments. Jha et al. [4] stated: "...the capital requirements and high maintenance costs as the primary barriers to implementation..." and "...despite broad consensus on the potential benefits of electronic health records and other forms of health information technology, U.S. health care providers have been slow to adopt them ..." In a survey carried out from March to November 2007, Huebner et al. [5] compared the use of clinical IT in Austrian and German hospitals by surveying all acute care hospitals of both countries (2172 in Germany and 130 in Austria). Among the 12.4% (n=270) of the German and 34.6% (n=45) of the Austrian hospitals that replied, their results showed a higher use rate (74.7%) of clinical IT in Austria compared to that in Germany (58.1%). The adoption rate of EMRs is 11.9% in Austria and 7.0% in Germany. Thus, the situation has changed only slightly since the Institute of Medicine's (IOM's) report on computer-based patient records (CBPR) in 1991 [6]. The forecast of adoption of CBPR in 10 years - until 2001 - failed dramatically [7, 8]. The IOM's update in 1997 for Europe [7] and the United States [8] concluded that no system existed that could fully replace the paper-based patient record.

However, new expectations concerning the benefits of EMRs emerge. Prokosch and Ganslandt [9] draw attention to the use of EMRs for clinical research. They state that databases of hospital information systems shall no longer be graveyards with terabytes of data rarely being looked at after the direct course of patient care. They affirm that it would be necessary to supply physicians with tools to uncover the treasures buried in hospital medical records and to apply those data for strategic management decisions and clinical research. Dean et al. [10] extend the use of EMRs to outcome research, thus reporting a six-fold increase of studies in this regard since 2000. The reported outcomes would vary across studies, depending on study objectives and the degree of EMR functionality. The majority of studies in outcome research use clinical data, pharmacologic data, utilization data, laboratory and imaging data. Dean et al. [10] stated: "It is clear that EMRs represent a convenient single source of rich data useful to researchers."

Being aware of the low adoption of EMRs on one hand and the unchanged high expectations on the other hand, we update in this paper our review from 2008 [1] to include studies from 2004 to 2010. To be comparable, hospital care was chosen as the

setting in this update as well. In the following sections, we present the literature review according to the recommended by Green [11].

2. METHODS AND MATERIALS

2.1. Definition

In this study, we adopt the following definition of EMR: An EMR is a "computer-stored collection of health information about a person, linked by a person identifier" [12], with the application environment being a hospital and any care delivery being the full responsibility of the health care provider.

2.2. Study Identification

This review is an update of a previous literature analysis about the benefits and costs of EMRs based on articles from 1966 to January 2004 [1]. In the current work, we included publications from February 2004 to 2010. We adhered to the same methods as in [1]. The literature search covered the period from March 10, 2010 through April 2, 2010, using MEDLINE. The MEDLINE database was accessed through the German Institute for Medical Documentation and Information (DIMDI, http://www.dimdi.de/).

2.3. Study Selection

Figure 1 presents an overview of the process of study selection. The following keywords from the National Library of Medicine's Medical Subject Headings (MeSH) were applied to cover electronic patient records, benefits and costs:

- Electronic Patient Record: Medical Record System, Computerized
- Benefit: Outcome Assessment, Patient; Outcome Study; Quality of Health Care
- Cost: Benefits and Costs; Cost Analysis; Cost Benefit; Cost Effectiveness; Cost Savings; Healthcare Cost; Costs and Analysis
- Cost and Benefit: Technology Assessment, Biomedical

First, the MeSH-term "Medical Record System, Computerized" was searched. Secondly, the results were successively combined by "AND" with the other MeSH-terms. Duplicates, non-English and non-German publications, reviews, and tutorials were deleted from the results. Date of publication was restricted from 2004 to 2010. The literature search revealed 578 articles (see Table 1).

We then examined these 578 articles based on the inclusion and exclusion criteria exhibited in Table 2. In the first stage, the articles were evaluated independently by two reviewers (i.e., both authors) on the basis of the abstracts. The evaluation criteria were specific statements about the EMR, its origination in an acute care hospital, and a publication based on an empirical study. This screening resulted in 64 articles worth analyzing.

Seven of the 64 selected publications were not available in German libraries. In the second stage, the full texts of the remaining 57 publications were examined independently by the same reviewers based on the inclusion criterion of containing specific statements about benefits and costs. Eight of these 57 publications were selected, with one of those excluded [13] because it was focused on the benefits of medical care provided in a neonatal department, not on those of an EMR.

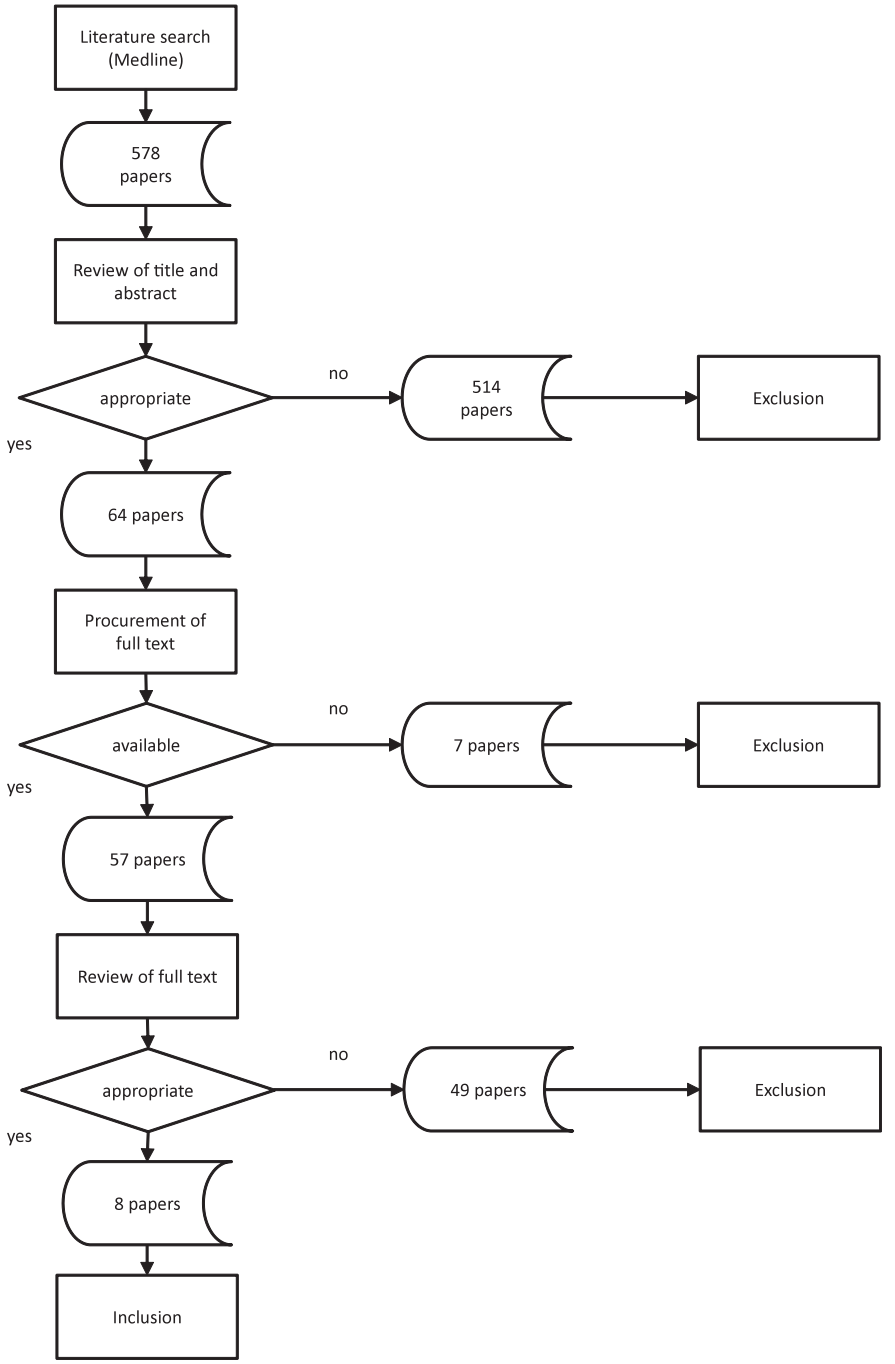

Figure 1. Flow of study selection.

Table 1. Result of the literature search.

MeSH-terms	Number of citations
Medical Record System, Computerized	15,892
Limitations applied:	
Outcome Assessment, Patient	266
Outcome Study	266
Quality of Health Care	452
Benefits and Cost	265
Cost Analysis	122
Cost Benefit	265
Cost Effectiveness	265
Cost Savings	141
Healthcare Cost	67
Costs and Cost Analysis	122
Technology Assessment, Biomedical	104
Total without duplicates, non-English and non-German publications, reviews, and tutorials	**578**

Inter-rater reliability during study selection was verified by calculating Cohen's Kappa according to the interpretation of Landis and Koch [14]. In the first stage, screening on the basis of abstracts, the Kappa value was 0.19, indicating a slight agreement between the reviewers, whereas in the second stage, screening of full texts, the Kappa value was 0.40, thus indicating a fair agreement.

2.4. Study Evaluation

Each study was evaluated in terms of the following aspects [15]: (1) study design, (2) formal quality of the publication, (3) number of the EMR users such as physicians and nurses, (4) duration of implementation, and (5) statistical evaluation. Each aspect of a study was rated 2, 1 or 0 points with 2 being the best and 10 being the maximum total score for a study. Missing information was rated 0 point.

Table 2. Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
Acute hospital	Physician offices
Inpatient care	Ambulatory care
Electronic medical record	Picture archiving and communication systems (PACS)
	Systems for computerized physician order entry (CPOE)
Empirical results	
Statement about costs	
Statement about benefits	

Table 3. Classification of study designs according to Roine et al. [16].

Evidence stage	Study design
1	Meta-analyses of randomized controlled trials
2	Large-sample randomized controlled trials
3	Small-sample randomized controlled trials
4	Non-randomized controlled prospective studies
5	Non-randomized controlled retrospective trials
6	Cohort studies
7	Case control studies
8	Non-controlled clinical series, descriptive studies, consensus methods
9	Anecdotes or case reports

Study design: The assessment of the design of each study was based on the classification depicted in Table 3, according to Roine et al. [16]. Different types of scientific studies are ranked from 1 to 9 concerning the evidence hierarchy. The first stage, meta-analyses from randomized, controlled studies, is not a component of the inclusion criteria. The remaining study types were combined into the following three groups: randomized controlled studies (evidence stages 2 and 3), non-randomized controlled studies (evidence stages 4, 5, 6, and 7), and uncontrolled clinical series, descriptive studies, consensus methods, application observations and empirical reports (evidence stages 8 and 9). Studies in the first group received 2 points, studies in the second group 1 point, and the remaining studies zero.

Formal quality of publication: The publication should follow the international standard structure of scientific articles, i.e., title with authors' names and affiliations on the title page, abstract, introduction, material and methods, results, discussion, conclusions, and references. For a publication in full compliance with this structure, two points were assigned; if the article followed the structure up to the introduction and mentioned authors and medical environment, 1 point was assigned; otherwise, 0 point was given.

Number of users: The number of EMR users can affect the reliability of the results. Two points were given for studies with 20 or more users, 1 point for 6 to 19 users, and 0 point for less than 6 users or if no number was specified.

Implementation duration: Studies implemented for at least one year received 2 points, 1 point was given for a half to one year, and 0 points for less than a half year.

Statistical evaluation: Two points were given for studies reporting the result(s) of statistical analysis/analyses with full information concerning the level of significance, and 1 point for the description of a statistical test performed without indication of the level of significance. Otherwise, 0 point was given.

3. RESULTS

3.1. Origins and Locations of the Studies

As summarized in Table 4, with four out of seven, the majority of the included studies are from Europe, where two are from Sweden [22, 23], one from Germany [21], and one from

Table 4. Summary of the included studies.

Authors	Year	Institution	Sample	Period	Outcome parameter	Costs reduction	Improved quality of care	Statistical evaluation
Deckelbaum et al. [17]	2009	Trauma Center of a tertiary care hospital and teaching facility in US	11,234 patients	36 months	Record completeness, revenue, mortality	Y	Y	Significance / χ^2 / Student's t-test
Donati et al. [18]	2008	12-bed medical and surgical ICU in Italy	24 patients, questionnaire; 49 physicians, 30 nurses, 25 consultants	70 weeks	Charting time, staff perception	Y	Y*	Significance / Student's t-test
Himmelstein et al. [19]	2010	US hospitals	Approximately 4,000 hospitals	NA	Administrative costs, quality scores	N	Y*	Significance
Kazley et al. [20]	2008	Nonfederal acute care hospitals in the United States	2,969 hospitals	NA	Quality performance indicators	NA	N	Significance / variance
Ndira et al. [21]	2008	A district hospital in Uganda	Several different samples of reports, mothers and staff members	18 months	Documentation quality, staff satisfaction	Y	NA	unpaired t-test
Øvretveit et al. [22]	2007	A large Swedish teaching hospital	30 senior clinicians, managers, project team members, doctors, and nurses	12 months	Staff perception	Y	Y*	NA
Pourasghar et al. [23]	2008	A medical university in Iran	600 records; interviews: 10 physicians and 10 nurses	10 months	Documentation quality, staff perception	Y	Y*	NA

Y: Yes. Y*: Yes, based on qualitative result. N: No. NA: not applicable or available. Entries arranged in alphabetical order of first author's last name.

Italy [18]. The United States are represented by three studies conducted in Cambridge, MA [19], Charleston, SC [20], and Miami, FL [17], respectively. Two studies stem from Germany and Sweden referring to hospitals in Uganda [21] and Iran [23], respectively. Three studies [17, 22, 23] were conducted in large hospitals and university clinics or affiliated institutions, and two in medium-sized or small hospitals [18, 21]. Two studies cover thousands of US hospitals in pooling data from different sources [19, 20].

3.2. Methodological Quality

Three studies [17, 21, 23] are non-randomized controlled trials, two studies [18, 22] are non-controlled clinical series, descriptive studies, consensus method studies, application observations and empirical reports (cf. Table 3). Two studies used existing data from secondary sources instead of original data collected from the EMR sites [19, 20]. Such secondary data analysis is not appropriately covered by the criteria defined by Johnston et al. [15]. For example, the number of EMR users and the study duration has to be checked in a non-conventional manner. The unit to be analyzed is the hospital, not the user of an EMR or the patient. Therefore, the assessment of the methodological quality includes only the remaining five studies, as listed in Table 5. Two studies [17, 18] received 7 points, and three studies [21, 22, 23] received 6 points. There was no randomized controlled trial among the selected studies. All selected studies followed the international standard structure of scientific articles and received 2 points each for formal quality. Two studies [22, 23] included at least 20 users of the EMR, one study [18] had 6 to 19 EMR users, and two studies [17, 21] did not report any information on the number of users. Three studies [17, 18, 22] lasted for at least one year, and two studies [21, 23] at least six months.

Five studies [17-21] supported their results by statistical analyses with full information concerning the level of significance (cf. Table 4), while two other studies [22, 23] did not present any statistical details. Both studies with the highest total score of seven are located in a specific sector of acute hospital care – trauma center [17] and intensive care unit [18].

3.3. Studies' Results

Table 5. Appraisal of the quality criteria.

Authors	Study design	Formal quality	User number	Running period	Statistical evaluation	Total score
Deckelbaum et al. [17]	1	2	NA	2	2	7
Donati et al. [18]	0	2	1	2	2	7
Ndira et al. [21]	1	2	NA	1	2	6
Øvretveit et al. [22]	0	2	2	2	NA	6
Pourasghar et al. [23]	1	2	2	1	NA	6

NA: Not available

All studies except one [20] cover economic aspects. Five of these studies indicate an economically positive impact, whereas one [19] concludes that implementation of EMR has no impact on administrative efficiency or overall costs. The main economic benefits are the reduction in time required for administration and archiving work as well as improvement of intercommunication among wards. Savings in nursing costs are indicated in three studies [18, 22, 23]. The negative result of Himmelstein et al. [19] is supported by a large number of included hospitals.

The impact of EMR implementation on the quality of care is addressed in six studies, with five indicating at least positive impacts even if not based on quantitative evidence; only one study [21] does not present any relevant information. One of the six studies dealing with the effects on treatment quality asserts that the use of EMR reduced the mortality rate, with a reduction of mortality rate from 8.96% in the year before the introduction of the EMR to 7.61% during the first 24 months after EMR implementation [17]. CARE, the EMR software used in the Trauma Division of The Ryder Trauma Center in Miami-Dade County in South Florida, USA, was developed at the University of Miami. This software not only provides the required templates and electronic notes of all clinical activities performed by the attending physician, but also meets the Centers for Medicare and Medicaid Services guideline requirements, thus minimizing any potential documentation discrepancy. The study of Kazley et al. [20] found no clear evidence that the EMR use could improve care quality. Like the study of Himmelstein et al. [19], Kazley et al. [20] analyzed secondary data from about 3,000 US hospitals focusing on acute myocardial infarction, congestive heart failure, and pneumonia. Applying a multiple regression model, they found a positive effect of the EMR use on four out of ten quality indicators and a negative effect on one out of those ten quality indicators.

4. DISCUSSION

Most publications suggest economic benefits provided by the implementation of EMRs. This conclusion remains nearly the same as our previous review [1]. Hospital costs can be substantially reduced if, after adoption of the EMR, administrative works such as nursing and charting time eventually decrease. Our previous review [1] covering studies up to early 2004 found only one [24] out of 20 studies with a negative economic impact, while in the present work, we found only one [19] out of seven studies with a negative result. However, neither study stated explicitly whether personnel cost savings are achieved by adoption of EMR. Purchase and maintenance costs of EMR systems and overhead for IT staff are not mentioned either.

Six out of seven studies assessed the effect of EMR on health care quality in comparison with four studies out of 20 in our previous work [1]. This represents a considerable rise of 66% (from 20% to 86%) of the publications addressing the impact on quality of care, suggesting a shift of the motivation for IT implementation to health care quality. The effects of adoption of EMRs on healthcare quality are consistently positive, with only one study in the current review indicating an unsatisfactory result [20]. Overall, there is sufficient evidence to support a statement made by the US President Obama in his weekly address on January 24th, 2009, that "we'll computerize the nation's health record ..., saving billions of dollars in health care costs and countless lives".

The small number of publications that satisfy the required inclusion criteria is startling. The authors expected an increase in studies on EMR implementation in acute care hospitals, driven by initiatives following, for example, the IOM's report about patient and medication safety [25]. There seems to be a gap between the power of EMRs on the one hand - supported by several studies with good methodological quality - and the interests of the buyers on the other hand. This gap is not only evident by the small number of studies found in the current literature survey, but also in the marginal implementation of EMRs in the United States, Germany and Austria [4, 5]. Moormann made a similar observation on the number of publications on EMRs [26]. The rate of publications (number of new publications added to the literature per year) increased in the early 1990's, and was stable in the second half of the 1990's. However, in the last decade, the rate of publications might have decreased. Furthermore, it is noted that the published studies present only results of correlations. It seems that either the studies do not intend to present causal statements beyond correlation analyses, or the quality of the study design (e.g., historical controls) does not allow any causal statement.

The origin and location of the studies changed considerably. In our previous review [1], 95% of the studies selected for evaluation were conducted in the United States, compared to only 43% in the current review with 57% at least organized in Europe.

The methodological quality of the studies increased from a median of 4 in the previous period to a median of 6 in the current one. Yet, there is still room for improvement. Some studies do not differentiate between medical quality, data quality, and quality of EMR implementation. Analyses of secondary data of thousands of hospitals were not present in the former review [1], although interestingly, the secondary data analyses included in the current review revealed cost disadvantages [19] and no effects on quality of care [20]. The current EMR implementations might be effective in their local environments, but it is questionable whether EMR as a technology tool is efficient from a broader, such as national, perspective.

We noticed that many of the excluded studies dealt with primary or ambulatory care, suggesting a shift of EMR implementation from acute hospital care to primary or ambulatory care, another possible explanation for the small number of included studies. On one hand, this shift may reflect a trend of EMR implementation as a successful and sustainable approach for cost reduction and quality improvement in primary or ambulatory care. On the other hand, this shift may reflect the search for an alternative market after a less than successful EMR implementation in acute hospital care. However, implementation of EMR in ambulatory care is still in its infancy. DesRoches et al. [3], for example, conducted a nation-wide survey among 2758 physicians (with a response rate of 62%) in the United States in late 2007 and early 2008. Thereby, they assessed physicians' adoption of outpatient electronic health records, their satisfaction with such systems, the perceived effect of the systems on the quality of care, and the main barriers for adoption. They found that 4% of the physicians had an extensive, fully functional EMR system; another 13% were equipped with a basic system. Most of the physicians reported an overall satisfaction with their EMR, and found the systems easy to handle in patient care. Primarily, financial considerations were the major impediments against the adoption of an EMR. According to Evans et al. [27], many

practitioners have hesitated to purchase EMRs, because they suspect that the costs of adopting such systems far outweigh the financial benefits.

4.1. Study Limitations

Inter-rater reliability during both the current and the previous studies was verified by calculating Cohen's Kappa with the interpretation based on Landis and Koch [14]. The comparison of the Kappa values of both studies in the first stage based on abstracts shows that the results of this study (0.19) was lower than the previous study (0.26). The Kappa value in the second stage based on full texts was higher in this study (0.4) than that in the previous study (0.36).

A reliable identification of appropriate publications remained an issue to be resolved. The studies do not offer a functional description of their EMR. Additionally, there was no reference model for EMRs consistently used by the included studies. Unfortunately, the five layer approach of Waegemann [28] is not common enough to guide the retrieval process. For example, it was impossible to identify whether "EMR" was interpreted as only an electronic counterpart of the paper file, or rather as a collection of different functions within a hospital information system. Further, the retrieval of literature depends on a correct tagging of publications on EMRs through the National Library of Medicine. The MeSH offers solely the old-fashioned term "Medical Record System, Computerized". The search might be more complete by looking for technologies in general and excluding other types of applications in a second step. Consequently, we cannot exclude a selection bias due to several factors. However, the large number of 15,892 hits using this term convinced us that we found an appropriate balance between recall and precision in the literature search. Furthermore, the results are at least comparable with our 2008 review [1] and supported by another report [29].

4.2. Suggested Future Research

The optimal study on the value of EMRs in hospital care should treat hospitals as observational units. A fully implemented EMR should be in place in the intervention arm. Hospitals without a fully implemented EMR then serve as controls. To the best of our knowledge, such a trial has not yet been performed. Because of the high complexity of each study, we suggest accepting EMR as a basic tool for hospitals and other health care providers. Further trials should concentrate on the assessment of complex interventions and their appropriate implementations.

5. CONCLUSIONS

The majority of the retrieved studies report economic advantages for hospitals as well as improvements of patient care quality with EMRs. For example, economic advantages are achieved by reducing staff time; improvements of quality of care are indicated by reductions of hospital mortality. The evidence for a positive effect on quality of care is a new finding of the current review. However, two large analyses of secondary data including thousands of US hospitals suggest that computerization does not reduce overall costs, and that only some quality indicators were affected by the implementation of EMR, both positively and negatively. The other studies typically cover only a small

part of hospital care, such as a department. Randomization is still not used in the study design. Broader and better designed studies are needed to establish better scientific evidence regarding benefits of EMR in hospital care. Nevertheless, this review and its predecessor support the current initiatives for a nationwide implementation of EMRs in several countries worldwide, such as the United States.

REFERENCES

[1] Uslu AM, Stausberg J. Value of the electronic patient record: an analysis of the literature. J Biomed Inform, 2008, 41(4), 675–682.

[2] Fletcher RD, Dayhoff RE, Wu CM, Graves A, Jones RE. Computerized medical records in the Department of Veterans Affairs. Cancer, 2001, 91(8 Suppl.), 1603–1606.

[3] DesRoches CM, Campbell EG, Rao SR, Donelan K, Ferris TG, Jha A, Kaushal R, Levy DE, Rosenbaum S, Shields AE, Blumenthal D. Electronic health records in ambulatory care - a national survey of physicians. N Engl J Med, 2008, 359(1), 50–60.

[4] Jha AK, DesRoches CM, Campbell EG, Donelan K, Rao SR, Ferris TG, Shields A, Rosenbaum S and Blumenthal D. The use of electronic health records in U.S. hospitals. N Engl J Med, 2009, 360(13), 1628–1638.

[5] Huebner U, Ammenwerth E, Flemming D, Schaubmayr C, Sellemann B. IT adoption of clinical information systems in Austrian and German hospitals: results of a comparative survey with a focus on nursing. BMC Med Inform Decis Mak, 2010, 10, 8.

[6] Dick RS, Steen EB. The Computer-Based Patient Record: An Essential Technology for Health Care. National Academy Press, Washington, 1991.

[7] Van Bemmel JH, van Ginneken AM, van der Lei AM. A Progress Report on Computer Based Patient Records in Europe. In: Dick RS, Steen B, Detmer DE, eds. The Computer-Based Patient Record. An Essential Technology for Health Care. Revised Edition. National Academy Press, Washington, 1997: 21–44.

[8] Tang PC, Hammond WE. A Progress Report on Computer Based Patient Records in the United States. In: Dick RS, Steen B, Detmer DE, eds. The Computer-Based Patient Record. An Essential Technology for Health Care. Revised Edition. National Academy Press, Washington, 1997: 1–20.

[9] Prokosch HU, Ganslandt T. Perspectives for medical informatics. Reusing the electronic medical record for clinical research. Methods Inf Med, 2009, 48(1), 38–44.

[10] Dean BB, Lam JN, Jaime L, Butler Q, Aguilar D, Nordyke RJ. Review. Use of electronic medical records for health outcomes research: a literature review. Med Care Res Rev, 2009, 66(6), 611–638.

[11] Green S. Systematic reviews and meta-analysis. Singapore Med, 2005, J. 46(6), 270–274.

[12] Waegemann P. The five levels of electronic health records. M.D. Computing, 1996, 13(3), 199–203.

[13] Skouroliakou M, Soloupis G, Gounaris A, Charitou A, Papasarantopoulos P, Markantonis SL, Golna C, Souliotis K. Data analysis of the benefits of an electronic registry of information in a neonatal intensive care unit in Greece. Perspect Health Inf Manag, 2008, 5, 10.

[14] Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics, 1977, 33(1), 159–174.

[15] Johnston ME, Langton KB, Haynes RB, Mathieu A. Effects of computer-based clinical decision support systems on clinician performance and patient outcome. Ann Intern Med, 1994, 120(2), 135–142.

[16] Roine R, Ohinmaa A, Hailey D. Assessing telemedicine: a systematic review of the literature. CMAJ, 2001, 165(6), 765–771.

[17] Deckelbaum DL, Feinstein AJ, Schulman CI, Augenstein JS, Murtha MF, Livingstone AS, McKenney MG. Electronic medical records and mortality in trauma patients. J Trauma, 2009, 67(3), 634–636.

[18] Donati A, Gabbanelli V, Pantanetti S, Carletti P, Principi T, Marini B, Nataloni S, Sambo G, Pelaia P. The impact of a clinical information system in an intensive care unit. J Clin Monit Comput, 2008, 22(1), 31–36.

[19] Himmelstein DU, Wright A, Woolhandler S. Hospital computing and the costs and quality of care: a national study. Am J Med, 2010, 123(1), 40–46.

[20] Kazley AS, Ozcan YA. Do hospitals with electronic medical records (EMRs) provide higher quality care? Med Care Res Rev, 2008, 65(4), 496–513.

[21] Ndira SP, Rosenberger KD, Wetter T. Assessment of data quality of and staff satisfaction with an electronic health record system in a developing country (Uganda). Methods Inf Med, 2008, 47(6), 489–498.

[22] Øvretveit J, Scott T, Rundall TG, Shortell SM, Brommels M. Improving quality through effective implementation of information technology in healthcare. International Journal for Quality in Health Care, 2007, 19(5), 259–266.

[23] Pourasghar F, Malekafzali H, Koch S, Fors U. Factors influencing the quality of medical documentation when a paper-based medical records system is replaced with an electronic medical records system: An Iranian case study. International Journal of Technology Assessment in Health Care, 2008, 24(4), 445–451.

[24] Neubauer AS, Priglinger S, Ehrt O. Electronic versus paper-based patient records: a cost-benefit analysis. Ophthalmologe, 2001, 98(11), 1083–1087 [in German].

[25] IOM: Kohn LT, Corrigan JM, Donaldson MS, Eds. To err is human. Building a safer health system. National Academy Press, Washington, 1999.

[26] Moormann PW, van der Lei J. An inventory of publications on computer-based medical records: an update. Methods Inf Med, 2003, 42(3), 199–202.

[27] Evans S, Stemple C. Electronic health records and the value of health IT. J Manag Care Pharm, 2008, 14(6, suppl S-c), 16–18.

[28] Waegemann CP. Current Status of EPR Developments in the US. In: Waegemann CP, ed. Toward an Electronic Health Record ´99. Medical Records Institute, Newton MA, 1999: 116–118.

[29] Shekelle PG, Morton SC, Keeler EB. Costs and Benefits of Health Information Technology. Evidence Report/Technology Assessment No. 132. (Prepared by the Southern California Evidence-based Practice Center under Contract No. 290-02-0003.) AHRQ Publication No. 06-E006. Agency for Healthcare Research and Quality April 2006, Rockville, MD.