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Triantafillou, Peter

Published in:
International Journal of Medical Informatics

DOI:
[10.1016/j.ijmedinf.2017.03.003](https://doi.org/10.1016/j.ijmedinf.2017.03.003)

Publication date:
2017

Document Version
Peer reviewed version

Citation for published version (APA):
Triantafillou, P. (2017). Making electronic health records support quality management: A narrative review. *International Journal of Medical Informatics*, 104, 105-119. <https://doi.org/10.1016/j.ijmedinf.2017.03.003>

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Making electronic health records support quality management: A narrative review

Peter Triantafillou

triant@ruc.dk

Department of Social Science and Business, Roskilde University, Denmark

Abstract

Background

Since the 1990s many hospitals in the OECD countries have introduced electronic health record (EHR) systems. A number of studies have examined the factors impinging on EHR implementation. Others have studied the clinical efficacy of EHR. However, only few studies have explored the (intermediary) factors that make EHR systems conducive to quality management (QM).

Objective

Undertake a narrative review of existing studies in order to identify and discuss the factors conducive to making EHR support three dimensions of QM: clinical outcomes, managerial monitoring and cost-effectiveness.

Method

A narrative review of Web of Science, Cochrane, EBSCO, ProQuest, Scopus and three Nordic research databases. Limitation: most studies do not specify the type of EHR examined.

Results

39 studies were identified for analysis. 10 factors were found to be conducive to make EHR support QM. However, the contribution of EHR to the three specific dimensions of QM varied substantially. Most studies (29) included clinical outcomes. However, only half of these reported EHR to have a positive impact. Almost all the studies (36) dealt with the ability of EHR to enhance managerial monitoring of clinical activities, the far majority of which showed a positive relationship. Finally, only five dealt with cost-effectiveness of which two found positive effects.

Discussion and conclusion

The findings resonates well with previous reviews, though two factors making EHR support QM seem new, namely: political goals and strategies, and integration of guidelines for clinical conduct. Lacking EHR type specification and diversity in study method imply that there is a strong need for further research on the factors that may make EHR may support QM.

Keywords: Electronic health record; Quality management; Implementation; Hospitals; Cost-effectiveness

1 Background

Since the 1990s many hospitals in the OECD countries have introduced electronic health records (EHR). For example, by 2012, nearly six in ten US hospitals actively exchanged electronic health information with providers and hospitals outside their organization [1], though hospital doctors in many countries have been slow to take up electronic information systems compared to general practitioners [2]. There are multiple goals behind the adoption of EHR systems, such as faster and easier access to clinical data, improved clinical outcomes, increased patient empowerment, and greater cost-effectiveness. Thus, EHR are often adopted because they are believed to enable the accommodation of several of these goals at once [3], though this belief has been contested as we shall see below.

A general rationale behind EHR is their potential of contributing to the improvement of quality management of health care provision [4]. It has been argued that consistent use of EHR may assist in further attuning medical interventions to individual patient needs [5], enhance patient safety [6] and improve wider quality management (QM) practices [7,8]. Notwithstanding the potentials of EHR to contribute to improve QM there is no guarantee that they will automatically improve quality or reduce costs [9,10]. The collection and utilization of data through EHR systems may produce a wide range of unintended and undesirable effects [11,12]. For example, poor data quality from EHR and ICT systems in general in the health sector has been estimated to be responsible for around 30% of patient safety incidents [13]. So far, few attempts have been made to synthesize the knowledge on the factors affecting the linkages between EHR and QM. The evidence underlying some of the existing synthesizing accounts on the conducive factors is either implicit or lacking [14]. Accordingly, there is a need to synthesize the existing empirically based research on the relationship between EHR and quality management.

This article undertakes a narrative review of existing studies of the relationship between electronic patient records and quality management systems at hospitals in OECD countries. The question guiding the review is: What factors are conducive to make electronic patient records support quality management at hospitals in OECD countries?

Fig. 1 shows three distinct research foci regarding EHR and its link to QM. As we shall see below, the existing research tend to focus either on the factors influencing the implementation of EHR (arrow 1). These studies are usually short-term studies focusing on the period immediately prior to and after adoption of an EHR. They rarely follow the everyday use of the EHR. Another line of studies examine the effects on EHR on quality — usually clinical effects or more rarely cost-effectiveness (arrow 2). Yet these studies say little about how — by what conditions or mechanisms — the EHR may contribute to the ongoing management of quality at the hospital. In other words, very few studies examine the intermediate factors that favour (or impede) the utility of EHR for QM purposes (arrow 3), which is the focus of this review study. By intermediate factors, I refer to the organizational and political context of the EHR, its technical contents, and the work processes involved in the EHR's everyday use.



Fig. 1 Research focus.

alt-text: Fig. 1

The focus on hospitals, rather than the health care system in general, is mainly due to practical considerations. Assuming that the functioning of EHR and QM systems are context specific, it seems prudent to pay attention to one type of intervention site, i.e. the hospital. Now, many EHR systems and QM systems are also designed to pay attention to patient treatment between hospitals, GPs, municipalities and other health care providers. Such studies will also be included in this study to the extent that they explicitly include hospitals. The term EHR (system) is used broadly to include any electronic record system containing individual patient data with a view to improve health care. Such a broad conception has the obvious drawback of including a number of quite diverse EHRs. Some systems include clinical decision-making guidelines, some do not; some include physician order entries, others do not; and some include modules enable patient participation in the care process, some do not. A fine grained typology of EHR systems could be useful to provide more in-depth understanding of the causal implications for QM. However, not only is there no generally accepted typology of EHRs, existing studies of EHRs are not always that clear about their specific design and organizational functioning. Thus, it is difficult to make a systematic review of EHRs and their link to QM. The present narrative review deals with this problem by accounting for and discussing the possible implications both of the type or functionality of the EHR systems found in the reviewed studies and of the particular method used in the reviewed study. This account is made both in the results section, where the intermediary factors are identified, and, in particular, in the discussion of the two intermediary factors that have not been mentioned by previous reviews.

The term QM is used very broadly and in different ways in the literature. This paper focuses on three dimensions: clinical outcomes, the managerial monitoring of clinical activities and the cost-effectiveness of clinical activities. These three criteria are chosen because they, in various forms, are widely shared concerns of both medical and management personnel at hospitals engaged in making sure that electronic patient records contribute to improve the quality of the services at their local hospital. Of course, the medical staff is more likely to emphasize the ability of electronic patient records to improve clinical outcomes, whereas as hospital managers tend to be more concerned with the ability to make EHR systems useful for monitoring and ensuring the cost-effectiveness of the medical activities at “their” hospital. Again, the three criteria are fairly general and may be specified rather differently. However, rather than coming up with very precise objective definitions, I rely on the subjective assessment of the journal article authors of the extent to which the electronic patient records systems meet these criteria. The disadvantage of such subjective assessments is of course that the authors may have quite diverse criteria for gauging success. Nevertheless, I decided to accept this as the use of very clear-cut and joint definitions would eliminate most existing studies from the review.

1.1 Existing review studies

10 existing reviews of EHR seem relevant for the present article. Three of these focus on the implementation process (arrow 1 in Fig. 1 above). If at all, they deal only indirectly with the relationship between EHR and QM. The seven other assess the effects, if any, that EHR have on quality/quality management (arrow 2 in Fig. 1 above). The 10 review studies are symptomatic of the compartmentalized focus of the reviewed studies. Most studies focus examine how EHR may be implemented or whether EHR's actually improve quality and quality management. Very few try to do both or to examine how the EHR may be linked to the everyday work of QM, i.e. after the initial implementation of the EHR system. The key contribution of this paper is to try to identify and review studies to better understand how — by what intermediate factors — EHR may be supportive of the everyday work of QM taking place in hospitals.

Three review studies focus on the *implementation* process. Firstly, a review of research on EHR implementation at hospitals found that 19 types of actions or conditions may be conducive to the implementation process [15]. These actions were divided into three groups: the context (hospital type, vendor selection, staff experience with ICT, organizational culture, hospital bureaucracy, and care activities); the content (fitting technology with work processes, hardware availability and system reliability, user friendly software, patient privacy safeguards, and vendor adaption); and the implementation process (active involvement of both management and clinicians, training of end-users,

comprehensive implementation strategy, resistance of clinical staff, finding champions, and adequate time and resources). These conducive conditions/actions resonate well with 10 general recommendations for how to contribute to effective EHR implementation issued by three leading scholars in the field [16]. These are: clarify what problem(s) the technology is designed to help tackle, build consensus, consider your options, choose systems that meet clinical needs and are affordable, plan appropriately, don't forget the infrastructure, train staff, continuously evaluate progress, maintain the system, and stay the course. Secondly, a review of the studies of users' attitudes to the barriers and facilitators of EHR system implementation concluded that the most frequent facilitating factors common to all user groups were design and technical concerns, ease of use, interoperability, privacy and security, costs, productivity, familiarity with and ability of the EHR, motivation to use EHR, patient and health professional interaction, and lack of time and workload [17]. Thirdly and finally, the findings of a review of studies of the implementation of EHR in health care organizations in general – not just hospitals – are interesting but also rather disheartening [18]. It concludes that the implementation of EHR 'requires a well-articulated vision and strategy, strong leadership, adequate resources, good project management, an enabling organizational culture, effective communication, and attention to human resource issues. Even when these preconditions were present, success was not guaranteed' (ibid. p. 751). Moreover, while EHR often hold functions that seek to reduce clinical errors, they may also generate a number of undesirable effects, such as cognitive overload, errors in data entry and retrieval, excessive trust in electronically held data, and the tendency to conflate data entry with communication (ibid. 759). These risks may obviously impede the successful integration of the EHR with useful QM. The study is a sober reminder that even under the most conducive circumstances, the implementation of EHR in hospitals is fraught with difficulties and may fail to ensure better QM and even be the source of new quality problems.

Seven reviews assess the potentially beneficial *effects of EHR* (arrow 2 in Fig. 1 above). The first of these is concerned with the impact of health information technology, notably EHR, on a range of quality dimensions [19]. The vast majority of the reviewed studies show that EHR improve quality by increasing adherence to guidelines, enhancing disease surveillance, and decreasing medication errors. The major efficiency benefit has been decreased utilization of care. Yet, it also found that cost data are limited and inconclusive, and that little evidence is available on interoperability. A second review found 70 studies indicating that structured electronic medical records often result in quicker data entry, improved data quality, and records that are useful in daily clinical work [20]. However, the structuration of records should be balanced with the clinical need for allowing to input context-dependent clinical data. A third study of the effects of EHR on nursing practice and patient outcomes found uncertain or equivocal results [21]. This review exposed several incidents of staff resistance to change their practices as they found that EHR are not supportive of their work [21]. The four remaining reviews of the potential benefits of EHR focus more narrowly on their impact on cost-effectiveness. They all show that there is a dearth of high quality studies of the cost-effectiveness studies. A recent review only found three relevant studies, all suggesting that EHR had potentials to improve cost-effectiveness [22]. Two other reviews found 26 studies, the majority of which report positive economic effects of EHR resulting from cutting the labour around paper-based patient records and the time spent on prescription and reporting [23,24]. The fourth review cautiously conclude that 'there is some evidence of value for money in selected healthcare organizations' created by some EHR systems [25]. None of these studies explain how EHR may be designed and implemented to maximize the cost-effectiveness of clinical activities.

The 10 review studies examined above provide a rather bleak message: while a number of factors are conducive to the implementation of EHR systems, the implementation process is fraught with pitfalls. Moreover, the number of studies focusing on the impact of EHR on quality management are quite limited and their results rather mixed. Accordingly, we should be wary of any success formula for adopting EHR for QM purposes. Nevertheless, it seems worth looking for the intermediate factors that may contribute to increasing the likelihood of success. In the following, I account for the method of the present review study, present the results, discuss these, and draw some conclusions.

2 Method

This paper will further develop the insights of the review by [15] by using the same three categories of factors influencing implementation. Moreover, some of the studies examined in the present paper are partly overlapping with the said review. The main difference is that the present study deals not only with the initial implementation process, but with the ongoing attempt – during and after implementation – to ensure that EHR link up with specific QM purposes.

The review conducted may be characterized as a narrative literature review or, more specifically, as a narrative overview [26,27]. It is narrative in the sense that it includes studies using a variety of quantitative and qualitative methods. By implication, the narrative review entails more qualitative assessments of the results produced by its review in the sense of being sensitive to the many contextual forces that may impinge on the results. The narrative literature review has been chosen because the area of EHR implementation is notoriously difficult to subject to review systematically due to very different research traditions and methodologies [18]. In particular, the tradition dominated by medical research focuses more or less exclusively on the clinical efficacy of EHR based on RCT style methods. Other more social science oriented traditions focus on a wide range of psychological, organizational and social forces shaping implementation, and allow for a wider range of methods studying such forces. The present narrative review is focusing on and therefore includes the latter approaches.

Yet, a narrative literature review certain does not mean that anything goes. It must operate with an explicit and rigorous approach. In the present review, the following approach has been followed: studies with a conceptual or theoretical ambition only have been excluded from this review. By the same token, only studies subjected to peer review are included, i.e. commentaries and editorial articles have been excluded. Moreover, studies dealing exclusively with the clinical outcomes of EHR are excluded. This is because the concern of this article is the factors that are conducive to make EHR supportive of QM in general. If the EHR is to succeed and survive at a hospital it should not only contribute to help curing patients. The data retrieved via the EHR should also be able to demonstrate that it does so by enabling systematic managerial monitoring of clinical outcomes. Moreover, to ensure the long-term survival of EHR, they should contribute positively to the cost-effectiveness of clinical services. Hence, the three QM dimensions dealt with in this article.

Database search for relevant academic journal articles was conducted between December 2015 and February 2016. Analysis of data was conducted from March to August 2016. The search for journal articles included Web of Science, Cochrane, ProQuest, Scopus and EBSCO. The Nordic countries are generally regarded as being relatively far ahead in implementing electronic patient record systems [28]. Hence, it seemed worth making an additional search for academic articles published in one of the Nordic languages only. The following Nordic research bibliographic databases were searched: The Danish National Research Database, the Norwegian Oria database found in Bibsys.no, and the two Swedish research databases Libris and Swepub. In order to reduce the risk of drawing on experiences from EHR systems based on obsolete technologies, only articles published from 2000 onwards were included.

A string was used to search for words occurring either in abstract or title or both. The search string was:

“Electronic patient record*” OR EPR OR ‘electronic health record*” OR EHR OR “electronic medical record*” OR EMR OR “patient* portal*” OR “personal health record*” OR ‘PHR” OR “medical record system*” OR “technolog* based health care deliver*” OR “health care infrastru*ct*” AND (“performance management” OR “quality management’ OR “quality assurance’). The Danish, Norwegian and Swedish words corresponding to the English terms listed above were used. The total number of articles found was 315.

The abstracts of the 315 articles were then read in order to examine their relevance for my research question. As already mentioned, articles with a conceptual or theoretical ambition only were excluded, as were non-peer reviewed articles. Finally, in accordance with the present focus on hospitals, all papers dealing with general practice/primary health sector only were excluded. This left 35 articles. The reference lists of these were perused to check for further relevant studies. Thereby, the total number of relevant studies came 39. As the overview in Table 3 below shows, the methods applied in these studies vary substantially: eight are either partially or wholly based on expert interviews, 15 are single case studies, 12 are multiple/comparative cases, six are surveys, and only one is a randomized controlled experiment. Moreover, only eight studies are longitudinal. The scarcity of longitudinal studies is significant as they are the only ones that allow us to examine whether or not an EHR that seems to be implemented successfully (in the short term) contributes to desirable outcomes (in the long term). Rather than ranking these studies according to their position in the evidence hierarchy, their reliability and generalizing potential will be discussed when assessing the validity of the intermediary factors they identify.

The 39 studies were analysed along two dimensions. Firstly, the intermediary factors that the studies explicitly reported as influencing the integration of EHR with QM in general were identified. In line with an existing review [15], these factors were placed into three wider groups, namely: context, content and process. Secondly, the specific QM aspects affected by the adoption of EHR were identified. In line with the definition above, the following three specific QM aspects were analysed: improvement of clinical outcomes, the enabling of systematic managerial monitoring of clinical activities and improvement of the cost-effectiveness of clinical activities. Thus, for each study, I examined what their assessments were of the three QM dimensions. Four codes were used: NEG if the study reported that the EHR contributed negatively to the aspect; POS if the study reported that the EHR had a positive impact on the QM aspect; AMB if a study showed both positive and negative (i.e. ambiguous) results; and NIL if the study did not report on the aspect, see Table 1 below. This admittedly crude assessment of the reviewed studies was applied because I rely on the subjective and therefore variable criteria of the authors of the reviewed studies. As mentioned above, the decision not to apply clear-cut, standardized definitions of positive/negative ‘clinical outcome’, ‘managerial monitoring’, and ‘cost-effectiveness’ is a pragmatic one as only very few of the 39 identified studies would survive such definitional streamlining.

Table 1 Quality management counts.

alt-text: Table 1

	Clinical outcomes	Monitoring	Cost-effectiveness
Negative (NEG)	12	7	2
Positive (POS)	14	27	2
Ambiguous (AMB)	3	2	1
Not studied (NIL)	10	3	31

Finally, I tried to tease out the link between the intermediary factors and the three QM dimensions, see Table 2 below. This was a difficult process as many of the 39 studies do not explicitly account for what QM dimension the EHR is contributing to. By implication, a simple binary coding was used: the value 1 in cases where the studies explicitly mention the EHR as contributing positively to the specific QM dimension; the value 0 where the study does deal with the link between the EHR and the QM dimension. It should be stressed that the latter does not mean that the factor is not important, only that it is has not been examined by the study.

Table 2 The importance of factors for making EHR supportive of QM dimensions.

alt-text: Table 2

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	Clinical outcome	Managerial monitoring	Cost-effectiveness
Political goals and strategies	1	1	0
Organizational settings	1	2	1
Data quality	6	8	1
User interface	3	5	0
Guidelines for clinical conduct	1	1	0
Address multiple purposes	3	3	1
Allocation of adequate resources	2	3	1
Participation of medical staff	4	4	0
Management engagement	3	4	1
Adaptation of work processes	4	4	0

3 Results

The review resulted in 39 relevant studies, see [Table 3](#) below for an overview. These studies explicitly point to 10 distinct factors as important for making EHR support QM. Two of these factors related to the hospital context (political goals and strategies, and organizational settings); four to the content of the EHR (data quality, user interface, guidelines for clinical conduct, multiple purposes); and four to the process during and after EHR implementation (adequate resources for implementation, participation of medical staff, management engagement, and adaptation of work processes).

Table 3 Overview of studies reviewed.

alt-text: Table 3

Study & country	EHR type/functions	Objective	Method	Data size	Key findings	QM
Bar-Lev 2015 [42] Israel	Not described	Examine how the use of EHR mediates knowing	Longitudinal single case.	1 hospital. 2 years duration	Management’s attempt to over-document clinicians’ know-how and decision-making processes may have pushed physicians to engage in defensive medicine. Nurses’ excessive documentation weakened their influence on clinical decision-making.	Clinical: NEG Monitor: POS Cost: NIL
Barr et al 2008 [48] USA	Generic	Provide benchmarking of operational and financial information, and national indices of oncology	Expert experience	35 oncology practices	14 benchmarks and 3 sets of indices were developed	Clinical: POS Monitor: POS Cost: NIL
Benson 2002 [2] UK	Generic	Explain variations in use of EHR between hospital and GP physicians	Expert experience. Multiple case	3 hospital sites	For more than 30 years, the GP profession has worked with government to provide incentives for computerizing practices and to remove barriers. In hospitals computing was treated as a management overhead, and doctors had no incentives to become involved.	Clinical: NEG Monitor: POS Cost: NIL
Campbell et al 2006		Identify types of clinical unintended adverse		Number of experts	Nine categories of unintended, adverse consequences were found. Identifying	Clinical: NEG Monitor:

[11] USA	Computerized order entry (CPOE)	consequences of (CPOE) implementation	Expert panel + Multiple case study	not given. 5 hospitals studied	and understanding the types and in some instances the causes of unintended adverse consequences will enable system developers and implementers to better manage implementation and maintenance of future CPOE projects	NIL. Cost: NIL
Cresswell et al 2012 [51] England	Not described	Understand how England's EHR software was integrated within the work practices of users in secondary and specialist care	Qualitative longitudinal single case study.	Interview of 66 health staff from February 2009 to November 2010	The nationally led "top-down" implementation and the associated focus on interoperability limited the opportunity to customize software to local needs. Lack of system usability led users to employ a range of workarounds unanticipated by management to compensate for the perceived shortcomings of the system	Clinical: NEG Monitor: NEG Cost: NIL
Cucciniello et al 2015 [59] Scotland	Not described	Obtain insights for managers planning EHR projects in the future	Single case using documents, interviews, observations	1 hospital with 25 medical wards	Lacking integration of IT systems, including EHR. Implications: Future planning should: consider the expressed needs and involvement of different actors; promote commitment to the system and adopt a participative approach; define and resource new roles within the organization capable of sustaining the change and (iv) assess system impacts in order to mobilize the network around a common goal	Clinical: NEG Monitor: NEG Cost: NIL
Darr et al 2003 [56] Israel	Standard, centralised EHR system for the entire hospital	Understand the managerial implications of the perceptions hospital physicians and nurses hold toward EHR	Single case study using depth-interviews	18 hospital physicians and eight nurses at 1 hospital	Senior physicians tended to emphasize managerial outcomes and to view these as positively. Junior doctors emphasized mostly negative occupational effects of the EMR on their work. Nurses identified different domains and saw benefits for quality and administration of patient care.	Clinical: NEG Monitor: POS Cost: NIL
Gall et al 2008 [50] Austria	Generic, but exemplified: CEN, HL7, openEHR	Understand the requirements that a system for cross-patient and hospital analysis should meet in a distributed healthcare system	Single case study	1 hospital	Archetypes can be utilized in data analysis for visualization, semantic linkage and finally for standardized data transfer.	Clinical: POS Monitor: POS Cost: NIL
Gunter and Terry 2005 [29] Australia and USA	2 systems: Push EHR: HealthConnect; Pull EHR: Consolidated Health Informatics	Identify reasons driving the development of EHR + challenges that health care providers in EHR implementation	Comparative case study using documents	2 countries	The Australian EHR is essentially a pull system, whereas the US ones are push systems. In both countries, federal policies and strategies importantly shape the decision by hospitals to adopt EHR.	Clinical: NIL. Monitor: NIL. Cost: NIL
Himmelstein et al 2010 [9] USA	Generic	Asses computerization's cost and quality impacts at hospitals	Survey of 4000 hospitals + administrative cost data + cost and quality data	4000 hospitals	As currently implemented, hospital computing might modestly improve process measures of quality but does not reduce administrative or overall costs	Clinical: POS Monitor: POS Cost: NEG
Hoerbst & Ammenwerth 2009 [43] International	Generic	Introduce a new model-based approach to structure and describe quality requirements of EHR	Literature analysis and expert interviews	63 publications + 26 experts	EHR systems should be customized to meet local needs. The new model differs from existing approaches as it accounts for modern software architectures and the special attributes of EHR.	Clinical: NIL Monitor: POS Cost: NIL
Hoerbst et al 2009		Identify the requirements				Clinical: AMB

[40] International	Generic	regarding quality certification of EHR systems	Expert interviews	29 experts from 5 European countries	There is a need for certification of EHR systems to ensure data quality	Monitor: AMB Cost: AMB
Hyun et al 2006 [37] USA	Eclipsys Clinical Information System (CIS) and the Columbia Medical Entities Dictionary (MED)	Evaluate the sufficiency of the Health Level 7 Identifiers, Names, and Codes document ontology for representing nursing document names	Single case study of EHR through document studies	94 nursing document types	79.8% nursing document names were completely represented and 20.2% were partially represented. In order for the document ontology to be of more use in implementing EHR that support nursing documentation, Subject Matter Domain and Type of Service axes require extension and clarification	Clinical: POS Monitor: POS Cost: NIL
Højen & Gøeg 2012 [36] Denmark and Sweden	Not described	Provide a clear methodology for SNOMED CT mapping to enhance applicability of SNOMED CT	Comparative study of templates from Danish and Swedish EHR	14 EHR templates from 5 Danish and Swedish EHR systems	The overall mapping rule is to represent related information homogenously by selecting concepts from the same sub-hierarchy. The guidelines provide a framework for achieving a consistent mapping procedure and thereby a well-defined foundation for data retrieval.	Clinical: NIL. Monitor: POS Cost: NIL
Højen et al 2013 [35] CHECK COUNTRY! Denmark and Sweden	Generic BESTILT FRA KB!!! 3. Feb. 17	Explore ways of supporting consistent use of SNOMED CT in EHR-system implementation processes	Single case testing of open source prototype	1 open source prototype	The open source prototype contains terminological features that are of relevance when exploring and comparing sets of concepts in SNOMED CT.	Clinical: NIL. Monitor: POS Cost: NIL
Håland 2012 [58] Norway	Not described	Examine how the introduction of the EPR affects the work practices and boundaries between various professional groups in the healthcare system	Single case study based on interviews	1 hospital + 18 interviews	EPR has become part of the professionals' boundary work; expressing shifting constructions of professional identities.	Clinical: NIL. Monitor: NIL. Cost: NIL
Johansen et al 2015 [41] Norway	Not described	Investigate quality-assurance work by medical transcriptionists in the production of medical records + the implications for EHR design	Single case study – based on focus groups interviews and survey	4 focus group interviews + Survey with 60 respondents	Many essential quality-assurance tasks conducted by medical transcriptionists and the extent of this work. We suggest that these correction and quality-assurance tasks need to be compensated for when designing and developing new structured EPR	Clinical: NEG Monitor: POS Cost: NIL
Landman et al 2012 [45] USA and Canada	Not described	Characterize motivations for adoption of EHR methods and the challenges they imply	Multiple case study using semi-structured in-depth interviews	23 interviewees from 20 EMS agencies	EMS agencies are highly motivated to adopt e-PCR systems to support quality assurance efforts; however, adoption and implementation of e-PCR systems has been challenging for many	Clinical: NIL. Monitor: POS Cost: NIL
Liaw et al 2012 [33] Australia	EDIS, a module of an EHR including modules for: scheduling, clinical info., results reporting, orders, discharge referrals, operating theatres	Examine the accuracy of the diagnoses of chronic diseases in a module of the NSW EHR system), and the consistency of the reports generated by the EHR	Comparative database study	1 database with 33115 attendees	Variations in information quality and consistency of the EDIS/EHR raise concerns about the 'fitness for purpose' of the information for care and planning, information sharing, research and quality assurance	Clinical: NEG Monitor: NEG Cost: NIL

Lorence et al 2002 [32] USA	Generic/clinical support systems	Examine and compare adoption rates of EPR data reliability within clinical support systems, and associated regional variation	National survey	8300 health information respondents	Low overall adoption of automated edits and significant variation across geographic regions and key organizational variables	Clinical: NIL Monitor: NEG Cost: NIL
Mikkelsen and Aasly 2005 [34] Norway	Not described	Assess the quality of information in EHR and the consequences of sub-optimal data quality on automated information retrieval	Single case study of EHR records	909 documents from 1 EHR system	Data attributes central for automated document retrieval in electronic patient records showed variable accuracy, with potentially negative consequences for basic record navigation. Text-based retrieval was inferior to methods based on data representing record structure. Quality of specific information elements suffered from lack of precise definitions and adequate mechanisms for quality assurance.	Clinical: NEG Monitor: NEG Cost: NIL
Mykkänen et al 2007 [61] Finland	Generic	Summarize a national study of eHealth standardization and make recommendations for the use of standards	Expert survey and literature study	Survey with 23 experts	A large number of recommendations were made. Some of the most important are: Shared national goals, policies and procedures for IT-related standardization must be specified. The primary preference must be given to cross-domain and generic standards. Healthcare-specific standards should be used only where they are essential	Clinical: AMB Monitor: AMB Cost: NIL
Nowin-ski et al 2007 [63] USA	EPIC system. Modules: longitudinal health data, results, orders, decision support, communication, patient support, admin. processes, reporting	Examine changes in organizational culture, quality improvement maturity, and quality of care following adoption of an EHR system	Longitudinal multiple case study + survey data.	5 work sites and 451 respondents. 12 months follow-up	Employees perceived the organizational culture as becoming more, rather than less, hierarchical. Moreover, quality indicators did not show improvement after year 1.	Clinical: NEG Monitor: NEG Cost: NIL
Ovretveith et al 2007 [52] Sweden	Not described	Describe the implementation of an EHR system in a hospital, the perceived impact, the factors affecting EHR implementation and success	Single case study	Interviews with 30 senior clinicians, managers, project members, doctors and nurses	Successful implementation, though inadequate time and resources slowed implementation. Implications: Implementation should be driven by top and departmental leaders assisted by competent project teams involving information technology specialists and users. Corrections for unforeseen eventualities will be needed, requiring regular reviews of progress and modifications to systems and timetables to respond to user needs.	Clinical: POS Monitor: POS Cost: NIL
Patel et al 2012 [31] USA	Not described	Assess the effectiveness of an EHR system in contributing to planning care for discharge of pediatric inpatients with asthma diagnosis	Cohort study Duration: 39 months	No. of asthma patients: Pre-EMR: 262. With EMR: 171.	Compliance with the plan of care discharge increased substantially after the introduction of EHR (from 65.3% for the 39 months before integration of the HMPC into EMR to 93.7% for the 18 months after integration)	Clinical: POS Monitor: POS Cost: POS
Poon et al 2003 [53] USA	Computerized physician order entry (CPOE) – only	Identify the barriers to CPOE implementation and the strategies for overcoming them	Multiple case study based on interviews with management officials	57 interviews at 25 hospitals	Costs and physician resistance as the two most significant barriers. Hospitals often overcome high implementation costs by placing patient safety at the top of their agenda. Other hospitals manage physician resistance by leveraging strong leadership, external influence, vendor commitment and the presence of house staff and hospitalists	Clinical: NIL Monitor: POS Cost: NEG
Proudlove and		Consider how information systems can be used to improve patient flow in acute hospitals, and the	Expert experience at the	More than 25 years	The National Programme for Information Technology specifies many features designed to support improving patient flows, though timescales for implementation are longer than those for the pledged flow improvements, and	Clinical: NIL Monitor:

Boaden 2005 [54] England	Generic	potential role of the National Programme for Information Technology	National Health Service and literature study	professional experience	operational use of this type of information system has been problematic in the National Health Service because of resistance from ward staff and other factors.	POS Cost: NIL
Purcell 2014 [38] USA	Generic	Examine the relationship between quality management standards (ISO 9000) and EHR interoperability	Survey: nonexperimental quantitative design	Survey of 399 health care professionals	Significant positive correlation between quality management and EHR interoperability	Clinical: POS Monitor: POS Cost: NIL
Rea and Rea 2002 [60] Wales	Not described	Change and improve service performance	Longitudinal questionnaire survey	4 surveys with a total of 409 respondents between 1998 and 2001	Change requires leadership to be dispersed across organizational boundaries. Accountability and responsibility must be horizontal and even downwards, not just upwards to government. Managing performance can ultimately enable services users to initiate and direct some of the improvements they want to see and to take part in the processes of change. The information systems must be locally useful for all involved, and must offer information about performance in time to affect improvement and change.	Clinical: POS Monitor: POS Cost: NIL
Rivard et al 2011 [57] Canada	EHR, CPOEs, admission, transfer, discharge, scheduling, test prescription, care plans, clinical notes, pharmacy services, decision support	Propose an organizational culture-based explanation of the difficulty of clinical information system (CIS) implementation and of the practices that may reduce this difficulty	Multiple case studies	3 cases, 43 interviews	All three cases showed resistance against EHR implementation from clinical staff. In two cases physicians resisted, while nurses supported the EHR. In the third case, the situation was the opposite. However, active management practices seeking to modify the EHR system and incorporate the concerns of the clinical served to alleviate resistance.	Clinical: AMB Monitor: POS Cost: NIL
Sheikh et al 2011 [30] England	Not described	Evaluate the implementation and adoption of the NHS detailed care records service in “early adopter” hospitals	Longitudinal qualitative evaluation based on multiple case studies with interviews, observations and documents.	12 NHS sites studied over 2.5 years. 431 interviews, 590 hours of observations, and 809 documents	Implementation proceeded more slowly, with a narrower scope and substantially less clinical functionality than planned. Delays related to unrealistic expectations about the capabilities of systems; the time needed to customize the software; the work needed to ensure that systems were supporting provision of care; and the needs of end users for training and support. Other factors hampering progress included the changing milieu of NHS policy and priorities; repeatedly renegotiated national contracts; different stages of diverse NHS care records service systems; and a complex communication between stakeholders.	Clinical: NEG Monitor: POS Cost: NIL
Smith et al 2013 [46] USA	Outpatient alert module and decision support	Develop a decision-support software prototype enabling individual and system-wide tracking of abnormal test result alerts lacking follow-up	Single case using formative evaluation of fit within the socio-technical system. Usability testing and interviews	Participants: 23 physicians, 9 clinical ICT specialists, 8 quality/safety managers	The software prototype fit within the technical environment and clinical workflow, and physicians were able to use it successfully. Quality/safety managers reported that the tool would be useful in future quality assurance activities to detect patients who lack documented follow-up. Additionally, we successfully installed the software on the local facility's “test” EHR system, thus demonstrating technical compatibility.	Clinical: POS Monitor: POS Cost: NIL
Taghavi et al 2013 [39] Australia and New Zealand	Clinical patient information and prescription orders	Audit the quality of patient notes and radiotherapy prescriptions	Longitudinal single case study of uro-oncology tumor	2597 patients were audited. Data collected from 1999 to 2009	Real-time audit with feedback is an effective tool in assessing the standards of radiotherapy documentation, and also probably contributed to the high level of attentiveness. A large proportion of omissions were investigation results, which highlights the need for an improved system of retrieval of investigation results in the radiation oncology department.	Clinical: POS Monitor: POS Cost: NIL
Takeda et al 2003		Assess the potential contribution of an on-line			The on-line reporting system has been effective to avoid adverse medical events. The quantitative methodology with the EPR is still in the phase of	Clinical: POS

[44] Japan	Examination reports, clinical data, orders.	incident reporting system and of an EHR system to quality management in hospitals	Single case study	1 hospital	developing. Direct data entry by medical staff and an EPR based on dynamic templates and a dynamic problem oriented approach could be useful for building clinical data repositories that can support clinical quality management	Monitor: POS Cost: NIL
Tang et al 2007 [49] USA	Generic	Compare quality measures calculated from administrative data to those derived from clinical data in an EHR	Randomized controlled trial	Sample of 125 charts of Medicare patients with diabetes	Only 75% of diabetics determined by manually reviewing the EHR (the gold standard) were identified. In contrast, 97% of diabetics were identified using coded information in the EHR.	Clinical: POS Monitor: POS Cost: NIL
Timmons 2003 [55] England	Not described	Investigate whether computerized systems designed to produce plans for the nursing care of inpatients, were resisted by the nurses	Multiple case study using semi-structured interviews with nurses	28 interviews at 3 hospitals	Resistance took the form of 'resistive compliance'. Resistance can best be understood in terms of the culture of nursing. This implies that the design and implementation of computerized systems in health care should take these factors into account.	Clinical: NIL. Monitor: POS Cost: NIL
Van Steenkiste et al 2002 [62] Netherlands	Generic	Develop and asses a method for selecting the content of an electronic patient record for asthma	Delphi-procedure – anonymous comments by expert panel	The expert panel was made up by 17 clinicians	The modified Delphi procedure, proved to be a feasible method for selecting the optimal content of an electronic registration protocol. Both, written and verbal commentary rounds were necessary. The existence of a set of guidelines was essential	Clinical: POS Monitor: POS Cost: NIL
Vermeulena et al 2014 [47] Netherlands	CPOE combined with clinical decision support	Study the balance between the effects and costs of CPOE/CDSS compared to the traditional paper-based medication ordering	Longitudinal comparative case study.	2 hospitals. 1195 patients studied from 2005 to 2008.	CPOE with basic CDSS contributes to a decreased risk of preventable harm. Overall, the extra costs of CPOE/CDSS needed to prevent one ME or one pADE seem to be acceptable.	Clinical: POS Monitor: POS Cost: POS
Aarts et al 2004 [64] Netherlands	CPOE	Understand the implementation of a computerized physician order entry system	Single case study	1 university hospital, 15 interviews	Full implementation of CPOE was halted due to unforeseen developments, such as the DRG system introduction, and user dissatisfaction with the interface. While implementation processes are unpredictable fit with everyday work processes of the clinical staff is essential	Clinical: NEG Monitor: NEG Cost: NIL

Before moving on to the 10 intermediary factors, it should be noted that only 12 of the 39 studies specified the type or functionality of the EHR under examination, see [Table 3](#). Moreover, the account for the type of these 12 EHR systems is in most cases quite rudimentary, though it is possible to detect that nine of these contained an ordering module and four contained clinical decision support functions. By implication, it is very difficult to assess if and how the particular type of the EHR impinge on the potential for improving QM.

3.1 Contextual factors

Two broad contextual factors seemed to be influential for making EHR support QM, namely political goals and strategies, and organizational settings.

3.1.1 Political goals and strategies

The decision by a hospital to adopt EHR and align it with its QM system is often driven by the goals of health policymakers. A comparative case study of EHR systems in the US and Australia shows that apart from health authorities, a number of other bodies, such as private quality standard agencies, private health providers and insurers, provide considerable impetus in certain political systems [\[29\]](#). Even when the adoption of an EHR system is driven more or less exclusively by a single health authority, the design, implementation and functionality of EHR at hospitals implementation may be affected by a host of political strategies and local political interests. A longitudinal multiple case study of the adoption national EHR in England showed that the adoption experienced substantial uncertainties and delays due to changes in NHS policies and targets and in the National Programme as a whole [\[30\]](#). On the one hand, then, political goals and strategies may be fundamental for the impetus to develop

and implement EHR and enable managerial monitoring. On the other hand, these goals and strategies, if too detailed and contradictory, may impede implementation.

3.1.2 Organizational settings

Care for individual patients often involves a number of health care institutions. Individual patients are often transferred between hospitals, general practitioners and municipalities offering rehabilitation services. Accordingly, according to a US cohort study of asthma treatment, EHR should cater to the various needs of these diverse health care institutions in order to improve the provision and health care quality management [31]. Complex organizational settings with many different health providers also create ample opportunity for inconsistent data reporting styles even if the same EHR system is used. A survey of EHR data reliability showed substantial regional (intra-country) variation in adoption and data quality control [32]. Thus, in order to enable systematic monitoring of clinical activities, hospitals using EHR systems should apply quality management systems or quality metrics to ensure the consistency of data.

3.2 Content factors

Four broad content factors seemed to be influential for making EHR support QM, namely data quality, user interface, integration of guidelines for clinical conduct, and addressing multiple purposes.

3.2.1 Data quality of the EHR system

Several studies of EHR database entry practices stress the importance of ensuring the *consistency* of clinical data entered into the EHR in order to ensure that it contributes to better quality management, notably better clinical outcomes [33–36]. The studies point out that while lower levels of consistency in data may not have any immediate (negative) effect on everyday clinical work and patient safety, insufficient consistency will negatively affect the utility of EHR for both quality management and research purposes. Not surprisingly, hospital settings operating with several – rather than one – EHR systems frequently give rise to inconsistent registration and use of data [37]. A comprehensive US survey study indicates that the use of QM systems, such as ISO 9000, may improve the interoperability of EHR data [38].

Like paper records, EHR systems may suffer from data *inaccuracy* or even erroneous data. A study of radiotherapy service suggests that real-time audit with feedback is an effective tool in assessing the standards of documentation [39]. More generally, based on a comprehensive expert survey, it has been argued that EHR systems should be certified in order to ensure their quality [40], though the evidence for the utility of this proposal is not very clear. The transition from paper records to EHR usually imply that medical transcription is abandoned in favour of physicians entering (writing) patient data themselves into the EHR. A single case study points out that the eradication of medical transcriptionists with the introduction of EHR may have a negative effect on data quality [41].

3.2.2 User interface of the EHR system

The standardized entries of the EHR system often disallows relevant and more or less complex verbal diagnostic accounts of a patient’s condition [42]. Accordingly, it has been argued that EHR systems should be *customizable* in order to meet the concrete needs for accounting for a patient’s symptoms in a clinically relevant fashion [43]. In line with one of the reviews mentioned above [20], it was found that an EHR based on dynamic templates and a dynamic problem oriented approach is useful for building clinical data repositories that can support clinical quality management [44].

Finally, registration of data in the EHR system should *not be too time consuming* as this may take away time for other important tasks such as the daily joint rounds and attention to patients [42]. For example, US ambulance drivers complained that the use of the new electronic system, which replaced paper records, is too time consuming and risk increasing ambulance run times [45]. Moreover, time constraints and heavy workloads implies that hospital clinicians at times overlook follow-up actions [46]. Thus, user-friendly based tracking and reminding function must be integrated in the EHR in order to improve follow-ups.

3.2.3 EHR guidelines for clinical conduct

Some but far from all EHR systems contain guidelines for clinical conduct with a view to improve ensure best clinical practice or more cost-effective practices, or sometimes both. It is an analytical problem that out of the 39 studies reviewed here, only nine specified that the EHR contain an ordering module and four contained clinical decision support functions. Of these, only one study examined the importance of EHR action guidelines for one of the QM dimensions, namely cost-effectiveness [47]. This longitudinal, comparative case study from the Netherlands found that EHR guidelines for clinical conduct on prescribing and ordering medicine improves cost-effectiveness.

3.2.4 Multiple purposes

EHR systems are often designed to meet *multiple purposes*, such as everyday clinical work, managerial responsibilities and research purposes. While clinical, managerial, research and other goals to be served by the EHR system are not necessarily mutually excluding, they may not always support each other either. US oncology quality managers have argued that the data generated by EHR systems may lend themselves to the making of meaningful clinical and cost-effectiveness indicators useful for benchmarking purposes [48]. This is supported by a randomized controlled study of US diabetes care, which concludes that the clinical data of EHR are superior to quality management purposes when compared to administrative data [49]. If an EHR is to cater for multiple purposes, it is crucial that these purposes be specified well in advance of the design of the EHR [50].

3.3 Process factors

Four broad process factors seemed to be influential for making EHR support QM, namely allocation of adequate resources for implementation, participation of medical staff, management engagement, and adaptation of work processes.

3.3.1 Adequate resources for implementation

Like any other large ICT system, it seems obvious to assume that the implementation of large EHR system requires substantial staff and other resources. Whether the transition is from paper-based to electronic records or from one EHR to another, this implies extensive organizational transformations. Not surprisingly then several studies point to the importance of mobilizing adequate time and financial resources [51,52] and sufficient human resources [52,53].

3.3.2 Participation of medical staff

Incidents of lacking support of and even resistance against use of EHR systems by medical staff is not unusual in the hospital sector [54,55]. Medical staffs react very differently to the introduction of EHR. Two studies suggests that physicians react quite differently from nurses [56,57]. A Norwegian case study shows that while physicians are often sceptical about the clinical value of highly standardized EHR, nurses, who have often never been allowed to fill in patient records before the advent of EHR, may use the latter to adopt a new job function and increase their status and authority vis-à-vis physicians [58].

In order to boost clinician support of EHR, the medical staff should participate in the design of the EHR and its uses in quality management [59]. A longitudinal study from Wales and a survey among Finnish physicians both conclude that medical staff should (also) contribute to the design of the standards guiding the structure and content of EHR in order to ensure the ownership and utility of the EHR [60,61]. A study of the design of an EHR system for asthma patient treatment showed that the use of a Delphi-method combined with direct dialogue enabled clinicians and IT specialists to agree on data relevance [62].

3.3.3 Management engagement



In order to enhance participation of medical staff and contribute to implementation more generally, the active engagement of the management before, during and after implementation is important [52,53]. Such engagement may serve both to address resistance from influential hospital physicians [57] and to stress the importance of the EHR for the hospital’s overall functioning. More specifically, implementation groups including representatives of all direct stakeholders in the implementation process is conducive to the design of an EHR system meeting relevant clinical and managerial concerns [59].

3.3.4 Adaptation of work processes




The adoption of EHR will more often than not induce *changes of existing work processes* at the hospital [63,64]. Such changes may very well obstruct quality gains unless carefully orchestrated. A longitudinal multiple case study from the US show that the introduction of a EHR system may contribute to making the organizational culture more hierarchical and make quality of care decline [63]. Accordingly, iterative trial-and-error of EHR system use after immediate implementation seems necessary for making EHR useful to QM. Two in-depth case-based studies conclude that implementation of EHR should be based on gradual re-invention of both the EHR and the existing work processes to meet the diverse needs of the users – both medical staff and patients [56,57].

3.4 EHR contribution to QM dimensions

The 39 studies suggest that EHR systems in various ways do contribute to QM. However, there are substantial variations of the contribution of EHR to the three QM dimensions analysed. Table 1 below shows the accumulated counts of the contribution of EHR to the three QM dimensions. Only very few studies included all three dimensions.

Table 1 shows that most studies (29) include clinical outcomes. However, only around half of these report EHR to have a positive impact. Almost all studies (36) deal with the ability of EHR to enhance managerial monitoring of clinical activities. The far majority found that EHR contribute positively to managerial monitoring in the sense that the EHR systems come with reporting functions allowing management to supervise clinical activities. However, only very few studies specified how  or the extent to which  EHR enhanced managerial monitoring. Finally, only five studies dealt with cost-effectiveness of which two found positive effects.

The 10 intermediary factors that seem to make EHR supportive of QM are not equally important. Some factors seem more important to one or more of the three QM dimensions than others. Table 2 below show whether the studies attributed importance to a specific factor for a specific QM dimension.

Table 2 suggests that all the 10  factors are important for making EHR supportive of clinical outcomes and of managerial monitoring. The table also reflects the very low number of studies examining cost-effectiveness. Accordingly, it is not possible to say much about whether or not the 10  factors contribute to cost-effectiveness. While it is beyond the scope of the present review to explore just how these 10  factors contribute to making EHR conducive

to the various QM dimensions, it is worth pointing out that many of the reviewed studies provide very useful insights on the causal mechanisms, cf. [Table 3](#).

4 Discussion

The findings of the present review study generally resonate well with existing reviews of EHR implementation and EHR consequences for quality (management), though with some notable exceptions. The review also revealed that any systematic assessment of the link between EHR and QM is very problematic because of highly diverse study methods and because of vague and in many cases even lacking specification of the EHR examined.

Eight of the 10 factors that this review found to be important for making EHR support QM were also identified by existing reviews of EHR implementation (organizational settings, data quality, user interface, multiple purposes, allocation of resources, participation of medical staff, management engagement and adaptation of work processes). There is at least two (and in most case more) studies in support of the importance of these factors for making EHR support QM. Accordingly, these will not be discussed further.

However, two factors, political goals and strategies, and integration of guidelines for clinical conduct were not mentioned in any of the review studies. The absence of these two factors from existing reviews seems rather odd as both factors appear intuitively important. A case study comparing US and Australian EHR and an English longitudinal multiple case study both concluded that the *political goals and strategies* pursued by governments, health authorities and other influential actors external to the hospital may be fundamental for the impetus to develop and implement EHR and enable managerial monitoring [\[29,30\]](#). The latter study found that if too detailed and contradictory, such goals and strategies may impede implementation. This factor was explicitly excluded from the search strategy in five out the seven existing review studies [\[15,19,23–25,65\]](#). It may be that the two other review studies have done the same, though this is not quite clear from their search strategy [\[17,18\]](#). Yet, the importance of external political goals and strategies resonate well with the observation made in the review by [\[18\]](#), namely that the presence of a number of conducive conditions internal in the hospital is no guarantee for successful EHR implementation. One reason for failing implementation under these otherwise beneficial circumstances could be that external political goals and strategies related to the EHR adopted by hospitals are too detailed, contradictory or both. With regard to the *integration of guidelines for clinical conduct*, only one study suggested that the EHR should contain guidelines informing the decisions and conduct of clinicians when prescribing and ordering medication in order to ensure cost-effectiveness [\[47\]](#). Even if this study was a thorough longitudinal, multiple case study, this is obviously not entirely convincing. Moreover, it remains unclear if and how the integration of clinical guidelines in EHR support the two other QM dimensions: clinical outcomes and managerial monitoring. Accordingly, there is a significant need for more studies to shed light on the conditions and factors whereby guidelines for clinical conduct and the other factors may contribute to better QM. Given that only few of the existing studies care to specify the type of the EHR examined, there is a particular need for studies accounting for the design and functionalities of the EHR examined.

The 39 studies suggest that EHR systems in various ways do contribute to QM. However, there are substantial variations of the contribution of EHR to the three QM dimensions analysed. Moreover, only very few studies included all three dimensions. Most studies (27) included clinical outcomes. However, only a bit more than half of these reported EHR to have a positive impact. This ambiguous finding resonates well with existing review studies of EHR implementation and consequences for quality. Almost all studies (36) reviewed here dealt with the ability of EHR to enhance managerial monitoring of clinical activities. The far majority found that EHR contributed positively to managerial monitoring. However, only very few studies specified how – or the extent to which – EHR enhanced managerial monitoring. A similar lack is found in the existing review studies. Thus, there is clearly a need for studies of the processes by which EHR affects cost-effectiveness. Finally, only five studies dealt with cost-effectiveness of which two found positive effects. This resonates relatively well with existing reviews, which found few rigorous studies of the impact of EHR on cost-effectiveness. The studies that do exist provide either strong indications [\[23,24\]](#) or ‘some evidence’ [\[22,25\]](#) of EHR contributing to cost-effectiveness improvements. In line with the present study, these four review studies all noted the scarcity of studies of the relationship between EHR and cost-effectiveness of clinical activities.

Finally, one may speculate in the existence of trade-offs between the three QM dimensions. For example, it seems fair to assume that increasing cost-effectiveness may come at the cost of declining clinical outcomes. Or, it may be speculated that clinical outcomes may improve even if managerial monitoring declines. Yet, the present review does not lend credence to such speculations. The two studies reporting positive effects of cost-effectiveness also reported positive clinical outcomes [\[31,47\]](#). Moreover, all studies reporting positive clinical outcomes, also reported improved managerial monitoring capacity, see [Table 3](#). In brief, EHR may – in fortunate cases – contribute to all three QM dimensions.

5 Conclusion

This narrative literature review has tried to systematize existing insights on how – by what intermediary factors – EHR systems may be linked to the everyday QM work taking place at hospitals. The review revealed that any systematic assessment of the link between EHR and QM is very problematic because of highly diverse study methods and because of vague and in many cases even lacking specification of the EHR examined.

Notwithstanding this qualification, this review found 10 factors to be important for this linking. Eight of these factors are also identified in existing reviews of EHR implementation and EHR consequences for hospital QM. Two factors, political goals and strategies, and integration of guidelines for clinical conduct were not mentioned in previous review studies.

There is substantial evidence indicating that EHR systems in various ways do contribute to improve QM. Yet, we also find substantial variations of the contribution of EHR to the three QM dimensions analysed here: clinical outcome, managerial monitoring and cost-effectiveness. Only very few studies included all three dimensions. Most of the reviewed studies (29) included clinical outcomes. However, only half of these reported EHR to have a positive impact. Almost all the studies (36) dealt with the ability of EHR to enhance managerial monitoring of clinical activities. The far majority found that EHR contributed positively to managerial monitoring. Finally, only five studies dealt with cost-effectiveness of which two found positive effects.

In sum, there is a strong need for further empirical research on the conditions, factors and processes by which EHR may support the everyday work of hospital QM in its various dimensions. Such studies should pay particular attention to specifying the type(s) of EHR examined.

Summary points

What was already known before this study

- Eight conditions or factors are important for the successful implementation of EHR in hospitals
- There are no guarantees of successful implementation even if these conditions are met

What this study has added to our knowledge

- Apart from the above mentioned eight factors, this study found that political goals and strategies, and the integration of guidelines for clinical conduct seem important to make EHRs contribute to quality management in hospitals
- There seems to be no trade-off in the ability of EHR to contribute to the three dimensions of quality: clinical outcome, managerial monitoring and cost-effectiveness

References

[1] M.F. Furukawa, V. Patel, D. Charles, M. Swain and F. Mostashari, Hospital ~~Electronic Health Information Exchange Grew Substantially In 2008~~electronic health information exchange grew substantially in 2008-12, *Health Aff.* **32**, 2013, 1346-1354 <http://search.proquest.com/docview/1428492301?accountid=14732>.

[2] T. Benson, Why general practitioners use computers and hospital doctors do not—Part 1: incentives, *Br. Med. J.* **325**, 2002, 1086-1089.

[3] D. Melchart, B. Wichmann, D. Polonius and R. Saller, Testing an electronic patient record for routine and evaluation of patient care, *Praxis (Bern. 1994)* **90**, 2001, 1587-1593 <http://www.scopus.com/inward/record.url?eid=2-s2.0-0035855987&partnerID=40&md5=379aa54f89b341cb7feb12c5ab1114c7>.

[4] G. Hoff, P.M. Ottestad, S.R. Skafłotten, M. Bretthauer and V. Moritz, Quality assurance as an integrated part of the electronic medical record a prototype applied for colonoscopy, *Scand. J. Gastroenterol.* **44**, 2009, 1259-1265, <http://dx.doi.org/10.1080/00365520903132021>.

[5] E.A. Kerr and R.A. Hayward, Enhancing ~~Value for Patients and Health Care Systems~~value for patients and health care systems, *JAMA J. Am Med. Assoc.* **310**, 2013, 137-138 <http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=88992279&site=ehost-live>.

[6] M.R. Silver and R. Lusk, Patient safety: a tale of two systems, *Qual. Manag. Health Care* **10**, 2002, 12-22 <http://www.scopus.com/inward/record.url?eid=2-s2.0-0036886601&partnerID=40&md5=d906c9af267b02eff0cb1614c6c2a62c>.

[7] J.D. Restuccia, A.B. Cohen, J.N. Horwitt and M. Shwartz, Hospital implementation of health information technology and quality of care: are they related?, *BMC Med. Inform. Decis. Mak.* **12**, 2012, 109.

[8] S.M. Elnahal, K.E. Joynt, S.J. Bristol and A.K. Jha, Electronic ~~Health Record Functions Differ Between Best and Worst Hospitals~~health record functions differ between best and worst hospitals, *Am. J. Manag. Care* **17**, 2011, e121-e147.

[9] D. Himmelstein, A. Wright and S. Woolhandler, Hospital computing and the costs and quality of care: a national study, *Am. J. Med.* **123**, 2010, 40-46, <http://dx.doi.org/10.1016/j.amjmed.2009.09.004>.

[10] A.M. Noblin, K. Cortelyou-Ward and S. Ton, Electronic ~~Health Record~~health record implementations, *Health Care Manag. (Frederick)* **30**, 2011, 45-50, <http://dx.doi.org/10.1097/HCM.0b013e3182078b4f>.

- [11] E. Campbell, D. Sittig, J. Ash, K. Guappone and R. Dykstra, Types of ~~Unintended Consequences Related to Computerized Provider Order Entry~~ *Unintended consequences related to computerized provider order entry*, *J. Am. Med. Informatics Assoc.* **15**, 2006, 547-556.
- [12] P. Rangachari, Using social knowledge networking technology to enable meaningful use of electronic health record technology in hospitals and health systems, *J. Hosp. Adm.* **3**, 2014, 66-78, <http://dx.doi.org/10.5430/jha.v3n6p66>.
- [13] A.C.M. Dumay and G. Freriks, Quality management issues for medical ICT, *Stud. Health Technol. Inform.* **103**, 2004, 93-100, <http://dx.doi.org/10.3233/978-1-60750-946-2-93>.
- [14] C.T. Hess, The ~~Power of an Electronic Medical Record: Documentation Drives Data~~ *power of an electronic medical record: documentation drives data*, *Adv. Skin Wound Care* **25**, 2012, 528 <http://search.proquest.com/docview/1170557545?accountid=14732>.
- [15] A. Boonstra, A. Versluis and J.F.J. Vos, Implementing electronic health records in hospitals: a systematic literature review, *BMC Health Serv. Res.* **14**, 2014, <http://dx.doi.org/10.1186/1472-6963-14-370>.
- [16] K.M. Cresswell, D.W. Bates and A. Sheikh, Ten key considerations for the successful implementation and adoption of large-scale health information technology, *J. Am. Med. Informatics Assoc.* **20**, 2013, e9-e13, <http://dx.doi.org/10.1136/amiajnl-2013-001684>.
- [17] C.A. McGinn, S. Grenier, J. Duplantie, N. Shaw, C. Sicotte, L. Mathieu, Y. Leduc, F. Legare and M.-P. Gagnon, Comparison of user groups' perspectives of barriers and facilitators to implementing electronic health records a systematic review, *BMC Med.* **9**, 2011, 46, <http://dx.doi.org/10.1186/1741-7015-9-46>.
- [18] T. Greenhalgh, H. Potts, G. Wong, P. Bark and D. Swinglehurst, Tensions and paradoxes in electronic patient record research: a systematic literature review using the meta-narrative method, *Milbank Q.* **87**, 2009, 729-788.
- [19] B. Chaudhry, J. Wang, S.Y. Wu, M. Maglione, W. Mojica, E. Roth, S.C. Morton and P.G. Shekelle, Systematic review: ~~I~~ *Impact of health information technology on quality, efficiency, and costs of medical care*, *Ann. Intern. Med.* **144**, 2006, 742-752.
- [20] K. Krüger, [Electronic medical records should be structured]. TT – Elektroniske pasientjournaler bør være strukturerte., *Tidsskr. den Nor. lægeforening Tidsskr. Prakt. Med. ny række*. 127 (2007) 2090-~~2093~~-*2093*. <http://search.proquest.com/docview/68200886?accountid=14732>
- [21] C. Urquhart, R. Currell, M. Grant and N. Hardiker, Nursing record systems: effects on nursing practice and healthcare outcomes (Review), *Cochrane Database Syst. Rev.* (1. A), 2009, <http://dx.doi.org/10.1002/14651858.CD002099.pub2>.
- [22] Z. Ahmed, N. Barber, Y. Jani, S. Garfield and B.D. Franklin, Economic impact of electronic prescribing in the hospital setting: ~~A~~ *a* systematic review, *Int. J. Med. Inform.* **88**, 2016, 1-7, <http://dx.doi.org/10.1016/j.ijmedinf.2015.11.008>.
- [23] A. Uslu and J. Stausberg, Value of the electronic patient record: ~~A~~ *a* analysis of the literature, *J. Biomed. Inform.* **41**, 2008, 675-682, <http://dx.doi.org/10.1016/j.jbi.2008.02.001>.
- [24] A. Uslu and J. Stausberg, Value of the electronic medical record for hospital care: ~~A~~ *a* review of the literature, *J. Healthc. Eng.* **2**, 2011, 271-283, <http://dx.doi.org/10.1260/2040-2295.2.3.271>.
- [25] J. Bassi and F. Lau, Measuring value for money: a scoping review on economic evaluation of health information systems, *J. Am. Med. Informatics Assoc.* **20**, 2013, 792-801, <http://dx.doi.org/10.1136/amiajnl-2012-001422>.
- [26] B.N. Green, C.D. Johnson and A. Adams, Writing narrative literature reviews for peer-reviewed journals: secrets of the trade, *J. Chiropr. Med.* **5**, 2006, 101-117, [http://dx.doi.org/10.1016/S0899-3467\(07\)60142-6](http://dx.doi.org/10.1016/S0899-3467(07)60142-6).
- [27] N. Clynych and J. Kellett, Medical documentation: ~~P~~ *p*art of the solution, or part of the problem? A narrative review of the literature on the time spent on and value of medical documentation, *Int. J. Med. Inform.* **84**, 2015, 221-228.
- [28] A. Hoerbst, W. Hackl, E. Ammenwerth, SeReM 2 – A meta-model for the structured definition of quality requirements for electronic health record services, in: *Stud. Health Technol. Inform.*, UMIT - University for Health Sciences, Medical Informatics and Technology, Research Division EHealth and Telemedicine, Eduard Wallnoefer-Zentrum 1, 6060 Hall, Austria, ~~2010: pp. 744-748.~~ *(2010) 744-748*. [10.3233/978-1-60750-588-4-744](http://dx.doi.org/10.3233/978-1-60750-588-4-744)

- [29] T.D. Gunter and N.P. Terry, The emergence of national electronic health record architectures in the United States and Australia: ~~M~~models, costs, and questions, *J. Med. Internet Res.* **7**, 2005, <http://dx.doi.org/10.2196/jmir.7.1.e3>.
- [30] A. Sheikh, T. Cornford, N. Barber, A. Avery, A. Takian, V. Lichtner, D. Petrakaki, S. Crowe, K. Marsden, A. Robertson, Z. Morrison, E. Klecun, R. Prescott, C. Quinn, Y. Jani, M. Ficociello, K. Voutsina, J. Paton, B. Fernando, A. Jacklin and K. Cresswell, Implementation and adoption of nationwide electronic health records in secondary care in England: final qualitative results from prospective national evaluation in early adopter hospitals, *BMJ* **343**, 2011, <http://dx.doi.org/10.1136/bmj.d6054>.
- [31] S.J. Patel, C.A. Longhurst, A. Lin, L. Garrett, J. Gillette-Arroyo, J.D. Mark, M.S. Wood and P.J. Sharek, Integrating the home management plan of care for children with asthma into an electronic medical record, *Jt. Comm. J. Qual. Patient Saf.* **38**, 2012, 359-365 <http://www.scopus.com/inward/record.url?eid=2-s2.0-84864255389&partnerID=40&md5=5efaa5aee97f2d6f990821abd0f3f5ad>.
- [32] D.P. Lorence, A. Spink and R. Jameson, Variation in EPR clinical support systems: data, decisions and disparity, *Health Informatics J.* **8**, 2002, 34-38, <http://dx.doi.org/10.1177/146045820200800106>.
- [33] S.-T. Liaw, H.-Y. Chen, D. Maneze, J. Taggart, S. Dennis, S. Vagholkar and J. Bunker, Health reform: ~~i~~s routinely collected electronic information fit for purpose?, ~~EmergMed. Australas. 24~~*Emerg Med. Aust.* **24**, 2012, 57-63, <http://dx.doi.org/10.1111/j.1742-6723.2011.01486.x>.
- [34] G. Mikkelsen and J. Aasly, Consequences of impaired data quality on information retrieval in electronic patient records, *Int. J. Med. Inform.* **74**, 2005, 387-394, <http://dx.doi.org/10.1016/j.ijmedinf.2004.11.001>.
- [35] R.A. Højen, E. Sundvall and R.K. Gøeg, Visualizing sets of SNOMED CT concepts to support consistent terminology implementation and reuse of clinical data, *Stud. Health Technol. Inform.* **192**, 2013, 1160 <http://search.proquest.com/docview/1418645567?accountid=14732>.
- [36] A.R. Højen and K.R. Gøeg, SNOMED CT ~~Implementation Mapping Guidelines Facilitating Reuse of D~~*implementation mapping guidelines facilitating reuse of* data, *Methods Inf. Med.* **51**, 2012, 529-538, <http://dx.doi.org/10.3414/ME11-02-0023>.
- [37] S. Hyun, R. ~~Ventura, S.B., Ventura, S.B.~~ Johnson, S. Bakken, Is the health level 7/LOINC document ontology adequate for representing nursing documents?, ~~i~~In: Stud. Health Technol. Inform., School of Nursing, Columbia University, 630W 168th Street GB 335, New York, NY 10032, United States, ~~2006-pp. 527-531. (2006) 527-531. h~~<http://www.scopus.com/inward/record.url?eid=2-s2.0-39049192444&partnerID=40&md5=edfec65a0881e174e14da4144441c507>
- [38] B.M. Purcell, Examining the relationship between electronic health record interoperability and quality management, *ProQuest Information & Learning, Learn*, 2014 <http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2014-99071-012&site=ehost-live>.
- [39] B. Taghavi Bayat, S. Gill, S. Siva, K.H. Tai, M.L. Joon, F. Foroudi, B.T. Bayat, S. Gill, S. Siva, K.H. Tai, M.L. Joon and F. Foroudi, Ten-year results of quality assurance in radiotherapy chart round, *BMC Health Serv. Res.* **13**, 2013, 148, <http://dx.doi.org/10.1186/1472-6963-13-148>.
- [40] A. Hoerbst, T. ~~Schabetsberger, W., Schabetsberger, W.~~ Hackl, E. Ammenwerth, Requirements regarding quality certification of Electronic Health Records, in: Stud. Health Technol. Inform., Research Division for eHealth and Telemedicine, UMIT – University for Health Sciences, Medical Informatics and Technology, Eduard-Wallnoefer-Zentrum 1, 6060 Hall, Austria, ~~2009-pp. (2009) 384-388. 10.3233/978-1-60750-044-5-384~~
- [41] M.A. Johansen, Å.-M. Pedersen and G. Ellingsen, The ~~Role of Medical Transcriptionists in Producing High-Quality D~~*role of medical transcriptionists in producing high-quality* documentation, *Stud. Health Technol. Inform.* **218**, 2015, 40607 <http://search.proquest.com/docview/1703698019?accountid=14732>.
- [42] S. Bar-Lev, The politics of healthcare informatics: knowledge management using an electronic medical record system, *Sociol. Health Illn.* **37**, 2015, 404-421, <http://dx.doi.org/10.1111/1467-9566.12213>.
- [43] A. Hoerbst, E. Ammenwerth, A structural model for quality requirements regarding electronic health records – State of the art and first concepts, ~~i~~In: Proc. 2009 ICSE Work. Softw. Eng. Heal. Care SEHC 2009, UMIT – University for Health Sciences, Medical Informatics and Technology, Research Division eHealth and Telemedicine, Austria, ~~2009-pp. 34-41. 10.1109/SEHC.2009.5069604. (2009) 34-41. 10.1109/SEHC.2009.5069604~~
- [44] H. Takeda, Y. Matsumura, K. Nakajima, S. Kuwata, Y. Zhenjun, J. Shanmai, Z. Qiyang, C. Yufen, H. Kusuoka and M. Inoue, Health care quality management by means of an incident report system and an electronic patient record system, *Int. J. Med. Inform.* **69**, 2003, 285-293, [http://dx.doi.org/10.1016/S1386-5056\(03\)00010-8](http://dx.doi.org/10.1016/S1386-5056(03)00010-8).

- [45] A.B. Landman, C.H. Lee, C. Sasson, C. Mv. Gelder and L.A. Curry, Prehospital ~~Electronic Patient Care Report Systems: Early Experiences from Emergency Medical Services Agency L~~electronic patient care report systems: early experiences from emergency medical services agency leaders, *PLoS One* 7, 2012, <http://dx.doi.org/10.1371/journal.pone.0032692> <http://dx.org/> <http://dx.org/>.
- [46] M. Smith, D. Murphy, A. Laxmisan, D. Sittig, B. Reis, A. Esquivel and H. Singh, Developing ~~Software to Track and Catch Missed Follow-up of Abnormal Test Results in a Complex Sociotechnical E~~software to track and catch missed follow-up of abnormal test results in a complex sociotechnical environment, *Appl. Clin. Inform.* 4, 2013, 359-375, <http://dx.doi.org/10.4338/ACI-2013-04-RA-0019>.
- [47] K.M. Vermeulena, J.E. van Doormaalb, R.J. Zaalc, P.G.M. Molb, A.W. Lenderinkd, F.M. Haaijer-Ruskampb, J.G.W. Kosterinkb and P.M.L.A. van den Bemtc, Cost-effectiveness of an electronic medication ordering system (CPOE/CDSS) in hospitalized patients, *Int. J. Med. Inform.* 83, 2014, 572-580.
- [48] T.R. Barr, E.L. Towle, D.H. Gesme, G. Hess, D.M. Hayes and W.M. Jordan, Quality measurement in oncology practices, *Community Oncol.* 5, 2008, 145-151 <http://www.scopus.com/inward/record.url?eid=2-s2.0-41149179152&partnerID=40&md5=304f45ecf78779400b65597f9171a09e>.
- [49] P.C. Tang, M. Ralston, M.F. Arrigotti, L. Qureshi and J. Graham, Comparison of ~~Methodologies for Calculating Quality Measures Based on Administrative Data versus Clinical Data from an Electronic Health Record System: Implications for Performance M~~ethodologies for calculating quality measures based on administrative data versus clinical data from an electronic health record system: implications for performance measures, *J. Am. Med. Informatics Assoc.* 14, 2007, 10-15.
- [50] W. Gall, W.~~Grossmann, G., Duftschmid, T., Grossmann, G. Duftschmid, T.~~ Wrba, W. Dorda, Analysis of EHRs for research, quality management and health politics, in: Stud. Health Technol. Inform., Medical University of Vienna, Spitalgasse 23, A-1090 Vienna, Austria, ~~2008, pp. 425-430. (2008) 425-430.~~ <http://www.scopus.com/inward/record.url?eid=2-s2.0-44349129077&partnerID=40&md5=9da65e1e4ba5d396b266f318792387e8>
- [51] K.M. Cresswell, A. Worth and A. Sheikh, Integration of a nationally procured electronic health record system into user work practices, *BMC Med. Inform. Decis. Mak.* 12, 2012, <http://dx.doi.org/10.1186/1472-6947-12-15>.
- [52] J. Ovretveit, T. Scott, T. Rundall, S. Shortell and M. Brommels, Improving quality through effective implementation of information technology in healthcare, *Int. J. Qual. Heal. Care* 19, 2007, 259-266.
- [53] E.G. Poon, D. Blumenthal, T. Jaggi, M.M. Honour, D.W. Bates and R. Kaushal, Overcoming the barriers to the implementing computerized physician order entry systems in US hospitals: perspectives from senior management, *AMIA Annu. Symp. Proc.* 2003, 975 <http://www.scopus.com/inward/record.url?eid=2-s2.0-16544378260&partnerID=40&md5=75792eb39cf45d80b63b9a686765528>.
- [54] N.C. Proudlove and R. Boaden, Using operational information and information systems to improve in-patient flow in hospitals, *J. Health Organ Manag.* 19, 2005, 466-477, <http://dx.doi.org/10.1108/14777260510629670>.
- [55] S. Timmons, Resistance to computerized care planning systems by qualified nurses working in the UK NHS, *Methods Inf. Med.* 42, 2003, 471-476.
- [56] A. Darr, M.I. Harrison, L. Shakked and N. Shalom, Physicians' and nurses' reactions to electronic medical records, *J. Health Organ Manag.* 17, 2003, 349-359, <http://dx.doi.org/10.1108/14777260310505129>.
- [57] S. Rivard, L. Lapointe and A. Kappos, An ~~Organizational Culture-Based Theory of Clinical Information Systems Implementation in H~~organizational culture-based theory of clinical information systems implementation in hospitals, *J. Assoc. Inf. Syst.* 12, 2011, 123-162.
- [58] E. Håland, Introducing the electronic patient record (EPR) in a hospital setting: boundary work and shifting constructions of professional identities, *Sociol. Health Illn.* 34, 2012, 761-775, <http://dx.doi.org/10.1111/j.1467-9566.2011.01413.x>.
- [59] M. Cucciniello, I. Lapsley, G. Nasi and C. Pagliari, Understanding key factors affecting electronic medical record implementation: a sociotechnical approach, *BMC Health Serv. Res.* 15, 2015, <http://dx.doi.org/10.1186/s12913-015-0928-7>.
- [60] C.A. Rea and D.M. Rea, Managing performance and performance management, *J. Manag. Med.* 16, 2002, 78-93, <http://dx.doi.org/10.1108/02689230210428643>.
- [61] J. Mykkänen, M.~~Korhonen, J., Porrasmaa, T., Tuomainen, A., Korhonen, J. Porrasmaa, T. Tuomainen, A.~~ Ensio, A national study of ehealth standardization in finland – Goals and recommendations, in: Stud. Health Technol. Inform., HIS RandD Unit, IT Services Centre, University of Kuopio, P.O.B. 1627, Fin-70211 Kuopio, Finland, ~~2007, pp. 469-473. (2007)~~

469-473. <http://www.scopus.com/inward/record.url?eid=2-s2.0-51849125988&partnerID=40&md5=516f7d902d7528b4346fc81ddf1ebda7>

- [62]** B.C. van Steenkiste, J.E. Jacobs, N.M. Verheijen, J.H. Levelink and B. Bottema, A Delphi technique as a method for selecting the content of an electronic patient record for asthma, *Int. J. Med. Inform.* **65**, 2002, 7-16, [http://dx.doi.org/10.1016/S1386-5056\(01\)00223-4](http://dx.doi.org/10.1016/S1386-5056(01)00223-4).
- [63]** C.J. Nowinski, S.M. Becker, K.S. Reynolds, J.L. Beaumont, C.A. Caprini, E.A. Hahn, A. Peres and B.J. Arnold, The impact of converting to an electronic health record on organizational culture and quality improvement, *Int. J. Med. Inform.* **76**, 2007, 174-183, <http://dx.doi.org/10.1016/j.ijmedinf.2006.05.016>.
- [64]** J. Aarts, H. Doorewaard and M. Berg, Understanding implementation: The case of a computerized physician order entry system in a large dutch university medical center, *J. Am. Med. Informatics Assoc.* **11**, 2004, 207-216.
- [65]** I.M. Miake-Lye, A. Amulis, D. Saliba, P.G. Shekelle, L.K. Volkman and D.A. Ganz, Formative evaluation of the telecare fall prevention project for older veterans, *BMC Health Serv. Res.* **11**, 2011, <http://dx.doi.org/10.1186/1472-6963-11-119>.

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