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Methods to Evaluate Health information Systems in Healthcare Settings: A Literature Review

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Abstract Although information technology (IT)-based applications in healthcare have existed for more than three decades, methods to evaluate outputs and outcomes of the use of IT-based systems in medical informatics is still a challenge for decision makers, as well as to those who want to measure the effects of ICT in healthcare settings. The aim of this paper is to review published articles in the area evaluations of IT-based systems in order to gain knowledge about methodologies used and findings obtained from the evaluation of IT-based systems applied in healthcare settings. The literature review includes studies of IT-based systems between 2003 and 2005. The findings show that economic and organizational aspects dominate evaluation studies in this area. However, the results focus mostly on positive outputs such as user satisfaction, financial benefits and improved organizational work. This review shows that there is no standard framework for evaluation effects and outputs of implementation and use of IT in the healthcare setting and that until today no studies explore the impact of IT on the healthcare system' productivity and effectiveness.

Keywords Evaluation studies · Medical informatics · Literature review

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Introduction

Information technology (IT)-based applications in healthcare have existed for more than three decades and have gained widespread use [1, 2]. Nowadays, it is hard to imagine healthcare without IT-based applications for both the accumulation and interchange of clinical information [3]. This is in part because IT has been recognized as an "enabler," that is, as a tool that offers solutions to the problem of the increasing accumulation of patient data [4, 5]. Because of their central role enabling the diverse use of information, IT systems ensure the timely and accurate collection and exchange of information, and thus a more efficient use of the scarce resources of healthcare organizations.

With an increased need for the implementation of IT in all healthcare domains—such as primary healthcare and clinical settings or home healthcare environments—for the purpose of providing an optimal use of resource investment, its use is expected to rise. Evaluating such ICT applications to help decision makers acquire knowledge about the impact of IT-based systems therefore becomes a key issue to all organizations that aim to implement any new application [6].

However, despite the fact that evaluation studies have increased in importance, they usually only provide answers to questions such as why the system should be studied, why a specific IT application should be chosen among many other systems, or why they only present a general picture about costs and benefits to both users and the organization [7]. Case studies that examine the costs and benefits of specific IT applications are the most common examples of empirical analysis, but the published work is neither extensive nor comprehensive. Studies discussing evaluation methodologies in the area of medical informatics have usually been performed descriptively, and often use

approaches from domains such as computer science, cognitive science, economics, and organization, and usually do not use in a multi-actor focus that includes the consequences of the implementation and use of IT-based systems for all participants, including care recipients and stakeholders, involved in the healthcare process.

The aim of this review is to outline the methodological approaches and results of studies that measure the impact of IT on healthcare organizations during 3 years (between 2003 and 2005). We limit the study to review evaluations of health information systems, including computer-based patient records, electronic health records, electronic medical records, telemedicine, and decision support systems.

Previous literature reviews

There are several previous literature reviews in the field of evaluation in medical informatics before 2003. They have, however, been conducted with several different aims, and their results are therefore difficult to compare. In this section we present three reviews relevant to this current paper; all related to the evaluation of effect of IT-based applications for either clinical decision support systems or computer-based patient records systems.

Kaplan [72] reviewed studies focusing on the evaluation of clinical decision support systems (CDSS), with the main emphasis upon changes in clinical performance and systems that could improve patient care. Kaplan's study includes many evaluations of CDSSs using designs based on laboratory experiments or Randomized Controlled Clinical Trials (RCTs). The author used Medline for a literature search from 1997 to 1998. In addition to this, a manual search identified 27 papers referenced frequently by other experts in medical informatics, and these are included in Kaplan's review. Kaplan concluded that conducting RCTs is the standard method of evaluation approach for CDSS. She argued that RCT-type studies could not be useful to investigate what influences whether systems are used. She also concluded that RCT-type studies do not answer questions such as why some systems tend to be used while others are not, why the same system may be useful in one setting but not in another, why a CDSS may or may not be effective, or why different results are obtained in different studies. For this reason, more research in this area is needed.

Ammenwerth and Keizer's [71] review identified the trend of evaluation research in the area of medical informatics from 1982 to 2002. The aim of the review was to answer questions such as which countries or journals dominate the evaluation research publications, which types of information systems have been evaluated, which aims have been studied in selected papers, which methods were applied for evaluation, how many papers have been published, in which locations and settings did the studies take place, and which evaluation strategy has been applied. Ammenwerth and Keizer's review was based on a systematic literature search in PubMed from 1982 to 2002, during which time 1,035 articles were selected. The authors concluded that the number of evaluation studies in the area of medical informatics is rising significantly. However, evaluation studies cover only around 1% of all medical informatics publications indexed in PubMed. Ammenwerth and Keizer noted that explanatory research and quantitative methods dominated evaluation studies during the period chosen for analysis. The most common, recurring aspects of the evaluation in the studies reviewed were appropriateness of patient care, efficiency of patient care, user satisfaction, and software quality. They showed that comparable development in medical informatics since 1982 was that the number of lab studies focusing on technical aspects was found to have declined. They also showed that focus upon the quality of care processes and patient outcomes was found to have increased. They interpreted this shift as a sign of the maturation of evaluation research in medical informatics.

Delpierre et al. [8] reviewed studies of computer-based patient record systems (CBPRS). The objective of their review was to carry out a systematic survey of studies analyzing the impact of CBPRS on medical practice, quality of care, and user and patient satisfaction. They reviewed selected papers published from January 2000 to March 2003, identified by their search through Medline, Cochrane, and Embase databases. They selected a total of 26 articles using this method. The authors concluded that they could show a better understanding of the relationship between the use of CBPRS and medical practice. An increased satisfaction of users and patients was noted, which could lead to significant changes in medical practice. They also noted that most of the studies did not include qualitative factors such as characteristics of the disease and the tool, the ward in which it was developed, and the relationship between various healthcare professionals, which could have an impact upon the use of CBPRS. Delpierre et al. [8] suggested in his study, a broad review including all the factors that may influence the success or failure of the use of CBPRS in medical practice.

Some notable differences between the included reviews

The following table categorizes the differences and similarities among the three reviews discussed above.

As can be seen in Table 1, evaluation studies have been performed with different aims and objectives, and are concerned with different domains and areas of focus. However, all of them are focused on identifying trends in evaluation studies, analyzing the impact of CPR, or to identify how

Table 1 Differences and similarities among Kaplan, Ammenwerth, and Delpierre's reviews

Review category	Kaplan review	Ammenwerth et al. review	Delpierre et al. review
Aim of study	How CDSS changes clinical performance	To identify trends of evaluation studies	Analyse the impact of CPR on medical performance
Domains in which systems are evaluated	Clinical area	National, Hospital, primary care, home care	Hospital, primary care, home care
Type of systems evaluated	Published articles which included CDSS from 1997 to 1998	All kinds of systems—included published articles from 1982 to 2002—only abstracts were reviewed	Published articles from 2000 to 2002 based on CPR, CDSS, and CPOE
Study design	Mostly RCT	All kinds of study designs	Mostly RCT
The approaches of papers which have been reviewed	Mostly quantitative approach	Both quantitative and qualitative, but quantitative methods dominated	Mostly quantitative approach
Focus of evaluation studies	Usefulness of system improved care with RCT and show RCT as a good method for evaluation	Appropriateness of patient care, user satisfaction, and software quality	Clinical practice, patient outcome, user and patient satisfaction

CDSS changes clinical performance. Despite the large number of studies included in the reviews, there are no studies that look specifically at the impact of IT on healthcare efficiency or productivity. Almost all evaluations are therefore partials, and the results are difficult to generalize from each particular study to a broader context. Most of the studies that explored the impact of IT considered decision support systems or electronic health records. The main benefits identified to quality are increased adherence to guidelines, better surveillance and monitoring, and decreased medical error. However none of the reviews found studies that have a clear impact on labor input or on the efficacy of the provision of care.

Materials and methods

A literature review was performed for published evaluation studies of IT-based systems in healthcare, including CPR (including EMR and EHR), telemedicine, and different kinds of DSS related to information systems like CPOE, between January 2003 and March 2006.

The search for the related material started in January 2006 and finished in March 2006. Linköping University's database was used to gain access to papers on this subject. The keywords used to search for the articles were: patient records, medical Records, health records, information technology, medical informatics, healthcare information, health informatics, hospital information system, patient care information system, CPOE, evaluation methods/theory, assessment, appraisal, information system/technology, economic evaluation, and evaluation study. In addition, the most important database, MEDLINE, was used to search for related papers. We conducted our search with the help of search rules, for example MeSH (major topic), language, publication type, and publication date.

The following strategy was used to select the articles from MEDLINE:

(1) We searched using the MeSH database, using the terms computerized patient records (CPR), decision support systems, clinical (DSS), and telemedicine.
(2) In the next step we searched MeSH for evaluation studies and found two categories called "evaluation studies" and "Evaluation Studies [Publication Type]."
(3) We combined step 1 and 2 according to the following details: ("Evaluation Studies"[MeSH] OR "Evaluation Studies"[Publication Type]) AND ("Medical Records Systems, Computerized"[MeSH] OR "Decision Support Systems, Clinical"[MeSH] OR "Telemedicine"[MeSH])
(4) We limited these reviews to articles published between 2003 and 2005 in English and with the aim of to evaluate some IT applications. We hit 674 articles.

We excluded papers concerning software and technical evaluation, as well as ethical and education-related evaluations. We also excluded some other evaluation articles that had no direct relationship with information systems, such as documentation and ordering through computers. Sixty-one articles were left at the end of this review process. Thirty-eight studies had been performed in hospital settings, 15 studies in primary care, and nine studies in homecare, with some of the studies performed in two domains at the same time. Two studies were performed in all domains (hospital, primary care and home care). Some projects, like IDEATel or Kaiser Permanente telehomecare, had a larger sample size and publication. However, we limited our review to this range, and excluded studies published before 2003 or after March 2006.

Results

In this section we will present a summary of the 61 published articles in the medical informatics area from 2003 to 2006 previously classified as evaluation studies. The following three tables present a brief description of the names of the authors, the domains the study was performed in, the design of each study, the time of evaluation, the sources of evidence, the aim of the study, and the findings. The studies are divided into the following main categories: CPR evaluation studies, telemedicine evaluation studies, and DSS evaluation studies. In Tables 2, 3 and 4 we summarize the evaluation studies classified as evaluation of CPR, telemedicine, and DSS:

Comments

Evaluations of CPR tend to be concerned with system usefulness regarding the quality of care, and user-related issues such as user acceptance and satisfaction and attitudes towards new systems, as well as the financial effects, usually limited to the identification of the costs of system implementation [9–11, 12–22].The inclusion of indirect costs is not a common procedure, at least, in the studies included in this literature review Usually the evaluations classified as "economic" include only the direct costs of the implementation of the new system [11, 14, 23].

Another important remark is that some of the studies included in this review tended to evaluate the effects of the new system's implementation on the quality of work performance, such as user job performance and computer knowledge, and investigation of skill among other users [24–28].

From Table 2 it can be seen that introducing a new computerized patient record system had found to have positive effects such as economic benefits [9, 11, 14], high acceptance score and satisfaction among the users in the implemented sites [10, 13, 16, 21, 24, 29] and also Improvements in management and work process [11, 16, 18, 22, 24, 28].

From Table 3 we can see that evaluations of telemedicine tend to be concerned with the economic effects of system implementation [30–34]. Usually the outputs are expressed as costs and benefits, or effectiveness in the telemedicine area. There are also, however, studies regarding user attitudes and perspectives, user satisfaction [35–38], and the usefulness of the system [30, 39–43], such as time of service delivery, usability, feasibility, and changes in the number of visits after implementation of the new system.

From Table 3 it can be seen that introducing a telemedicine system had positive effects such as reducing spent time per patient during the visiting by clinical staff [41, 42], economic benefits [30, 31, 39], and also quality of care [30, 39, 42, 44].

Table 4 provides insight into some issues regarding evaluations of DSS. It can be seen from Table 4 that most of the systems that have been evaluated are CPOE, with the aim being to evaluate the usability of systems [45–49] or the effectiveness of the system for patients [32, 50–53]. Some of the studies reviewed tend to also evaluate the financial impacts of introducing the new system [54, 55] thus without systematic identification of all costs. There are even some in this area that included measures of user satisfaction and attitudes towards the system [31, 56].

From Table 4 it can be seen that introducing a clinical decision support systems in healthcare organizations had positive effects such as improved quality of care [46–49], satisfaction among users in the implemented sites [56], and also improvements in management and work process [45, 50, 52, 57].

However, most of the studies did not discuss a specific theory to be applied when evaluating IT-based applications in healthcare. Few studies presented discussion of some economic theories such as cost-benefit/effectiveness analysis [9, 31–33], and none generated new theories or extended olds ones.

It is also interesting that many studies used formative tests as an evaluation method, and a high proportion of studies used summative tests. Moreover, more than half of the papers used summative tests simultaneously. Focusing on most of the articles included in our study, we find that they have used objective and subjective perspectives simultaneously.

Most of the studies based on the financial model, like cost-benefit/effectiveness, showed that there were improvements with the introduction of the new systems, especially in the telemedicine area. In contrast, some studies showed that the implementation of new DSS or Telemedicine had no economic benefits [32, 33, 54], and few showed that the introduction of the new CPR or DSS were problematic [58–61].

Discussion

The purpose of this paper was to conduct a literature review focusing upon the evaluation of IT-based systems in healthcare. The results show that several similar studies have been performed that focus upon clinical support systems, CPR for medical practice, telemedicine, decision support systems, etc. Previous review studies concluded that experimental designs are excellent for studying system performance or changes in clinical practice behaviour, but noticed that evaluation approaches such as usability testing, cognitive studies, ethnography studies or socio-technical

Table 2 CPR evaluation studies

Authors	Domain	Study design	Time of evaluation	Source of evidence	Aim of studies	Finding
Samuel J. Wang et al. [2003] [9]	Primary care	Survey	After implementation	Economic data on costs and benefits came from patient medical records –Expert opinion	To estimate the net financial benefit or cost of implementing electronic medical record systems in primary care during a period of 5 years.	This study shows that a positive benefit of about $86,400 was obtained by the organisation over the period of 5 years. The implementation cost involved in the whole process was $ 46,400 and categorized into two types of costs: system cost (system implementation, support and maintenance, and hardware); and induced cost (those involved in transmission from paper to electronic system). The benefits obtained, were categorized as; A) payer-independent benefits (obtained from the factors such as chart pull and transcription); B) capitated patient benefits (e.g. from the advance drug events; from the utilization of drug laboratories and radiology); and C) fee-for-service patients (which included better charge capture and reduced billing costs due to less errors.) Significant benefit factors were found to be: savings in drug expenditure by 33%; the reduction in the utilization of radiology by 17%; improvement in the capture of charge and decrease in billing cost which equalled to 15% each of the total benefits.
Hallvard Laerum et al. [2003] [10]	Hospital	Survey	After implementation	–Questionnaire (open ended questions) completed by 70 physicians –Interview with 8 physicians	Evaluating the effects of scanning and elimination of paper based records by studying physicians and their attitude toward the system	This study shows that scanning and eliminating paper based medical records were found to be acceptable, as it provided access to the old medical records in the form of an image for the document. The study also shows that scanning papers are being used with a high frequency, but it is considered only an intermediate stage towards having full access to the records. This study shows positive results regarding the performance of the medical tasks and user satisfaction. The use of the system as a whole was found to offer satisfactory functionality, i.e. for information retrieval, for example, 9 out of 11 tasks become easier to perform. Moreover, physicians also found it easier to work with the system whereby part of the system handling was combined with the regular electronic data. However, not all physicians were found to be satisfied with the use of electronic medical records due to basic drawbacks such as,

Table 2 (continued)

Authors	Domain	Study design	Time of evaluation	Source of evidence	Aim of studies	Finding
						more navigation time is required when accessing the data as compared to the time used in direct interaction, and there is limited functionality of the scanned images due to the rigid structure of the system.
Cornelia M. Ruland et al. [2003] [11]	Hospital	Cohort	After implementation	–Economic data extracted from nursing records –Semi structured Interview (7 nurse managers) –Focus group with nurses –Questionnaire to 7 nurse managers	To describe the effects of the new system for evaluation on: cost reductions; financial management, and decision making	This study shows that during the evaluation period of 4 months, the implementation of CLASSICA had an overall positive impact on effective nursing resource management. During the evaluation period test, units had a 41% reduction in expenditure compared with the average expenditure before the introduction of the new system. This means that the implementation of the system resulted in better-cost management. A significant improvement in information management was also noticed. It was also observed that it became easier to analyse the relationship between patient activities, staffing, as well as the cost of care. High user satisfaction with the system and the information and decision support it provided was observed. The system was found to be easy to use. The interviews regarding the ease of use and user satisfaction revealed, according to the authors, positive results. It was also observed that it had become easier to recognize the causes and explanations for bad and good resource management.
Adams W.G. et al. [2003] [64]	Hospital and Primary care	Pre–post intervention analysis	Before and after implementation	Review of medical records (235 paper based visits and 986 computer based visits documents)	To evaluate the quality of documentation and delivery of paediatric primary care before and after the implementation of an EMR	The findings of study show that users were prompted to ask about risk factors and could see by the template design that, their answers would be available at the next visit, these items are frequently lost. The quality of anticipatory guidance also improved considerably. The outputs of the system were well accepted by families. Nearly all users also agreed that the system improved the quality of guidance given to families. Clinicians are often overwhelmed by time limitations in the primary care setting. The electronic medical records (EMR) improved the completeness of delivery of age appropriate

						guidance. Also 6 of the 7 clinicians, who use computer-based records, reported using the system for 95% to 100% of nonurgent care visits. Nearly all users agreed that the system was easy to use, increased completeness, and reminded them to do things that they might otherwise forget. 4 of 7 users felt that the system extended the duration of visits. Most users also agreed with the statement that use of the system reduced eye-to-eye contact. All users agreed that the system should continue to be used.
Houston T.K et al. [2003] [12]	Hospital	Survey	After implementation	Interview with 93 patients and 82 physicians	To survey patients' perceptions of handheld computer use by physicians, and compare those with their providers' perceptions	The findings of this study show that the general attitude towards computers in the examination room was positive and generally patients at that clinic had positive attitudes toward handheld computers. 33 patients who never used computers less frequently reported that they liked the idea of residents using handheld computers compared with those who did use computers. Patients whose physician had used a handheld computer had a significantly more positive attitude toward handheld computers. The patients expressed that the use of handheld computer could be very useful in helping them to improve the care that they received. 66% physicians agreed that there was enough time to use the handheld computer in the clinic practices. Some physicians (23%) reported reservations about using the handheld with patients.
Elske Ammenwerth et al. [2003] [13]	Hospital	Cohort	Before and during and after implementation	–Questionnaire completed by 39 nurses –Interview with 12 nurses	To evaluate the preconditions and consequences of computer-based nursing process documentation with a special emphasis on acceptance issues among nurses.	This study shows that significantly high initial acceptance scores were observed in all wards before the introduction of the computer based documentation system. A difference between the psychiatric wards and the somatic wards was noticed with a higher initial acceptance score for the somatic wards, as the psychiatric wards were nearly completely electronically documented. No overall changes in the acceptance scores were noticed during the study, however rather higher mean scores were observed on all wards. The introduction of the computer-based documentation, however, did not seem to have any measurable influence on the general acceptance of computers. Acceptance scores from medium-to-high were

Table 2 (continued)

Authors	Domain	Study design	Time of evaluation	Source of evidence	Aim of studies	Finding
						observed after the implementation. In the case of ward C (one of the wards) the initial acceptance scale declined and then rose again. It was noted that mean scores typically decreased after the introduction of the system, as seen in other studies, thus showing a decrease in the attitude towards its use over time at the intermediate stage. The level of acceptance by the users was observed to be ranging from medium to high. The majority of the interviews showed their likeness towards the continuation of work with the PIK in the future. Thus, the overall acceptance scores were quite high and were found to rise, except in the case of ward C. The higher acceptance scores were found to be correlated with the nurse's years of computer experience, as well as with the higher initial scores. No initial knowledge of computer, lack of confidence in use and old age of staff were thought to be the reasons behind the lower scores in the case of ward C. Thus, it was concluded that computer knowledge and previous acceptance of nursing processes were the prerequisites for the high results regarding use and acceptance of the system.
W. P. Zhang et al. [2004] [14]	Hospital	Survey	After implementation	Questionnaire open-ended questions to 81 hospitals	To clarify the implementation and maintenance costs of a computerized patient record (CPR) system in hospitals	The findings of this study indicate that CPR systems improved the hospital administration and medical examinations practices. It was found that the designer of the system had the greatest impact on the per bed implementation among the various factors surveyed. Number of servers, institution type, and implementation date also played an important role in the per bed implementation cost. The examination of per bed implementation cost by hospital size showed that the mean cost tended to be the lowest for mid-size hospitals but higher for small as well as large hospitals. Examination of annual maintenance costs against total implementation, however, showed no difference among the three sizes categories. More than 60% of the users (hospital directors, system managers,

						nurses and general staff members) responded with "very high" or "high" satisfaction. An overall improvement in the medical care was observed by the introduction of CPR system. From the improved hospital administration (with 80% positive response), user satisfaction (with 54% positive response) and better presentation of information (with 75% positive responses); the overall optimistic attitude was found to be evident. However, a big percentage of 82% responded negatively regarding the disadvantages of CPR i.e. confusion on installation, poor user friendliness, and increased staff workload during learning and training.
Laerum H et al. [2004] [15]	Hospital	Survey	After implementation	–Questionnaire completed by 79 medical secretaries, 172 nurses, 70 physicians –Interview with 8–12 representative medical secretaries, nurses, physicians	To evaluate use of and attitudes to a hospital information system by medical secretaries, nurses, and physicians	The findings show that the nurses and the physicians use the HIS much less than the medical secretaries. The medical secretaries reported, however, that all defined tasks regarding computer-based applications were performed more easily than paper-based application. The nurses and physicians noted that the electronic hospital information system has less simplified their work than medical secretaries. The medical secretaries were much more satisfies with the use of the HIS than the nurses and physicians, particularly with the use of scanned document images. The secretaries gave significantly more positive responses than the nurses and the physicians to HIS. Nurses and physicians were less satisfied with using the system. The most frequently reported problems among the physicians consisted of various software and hardware-related problems, the system working too slowly, and lack of computers where the clinical work was being done. Both nurses and physicians in the medical ward found that patient data were more accessible when stored electronically than when stored on paper, in particular regarding lab test data.
Daniel B. Hier et al. [2004] [16]	Hospital	Survey	After implementation	Questionnaire distributed to 330 faculty and house staff physicians (closed and open ended questions)	To determine whether any differences exist between house staff and faculty physician's acceptance of an electronic health record system.	The study shows that the user acceptance of the EHR was high (86%) for both faculty physicians and house staff physicians. However, house staff physicians showed significantly higher frequency; 88% preferred the EHR to a paper record and 75% said they enjoyed using the EHR. 64.7% of the faculty members indicated they prefer it and 60.6%

Table 2 (continued)

Authors	Domain	Study design	Time of evaluation	Source of evidence	Aim of studies	Finding
						showed their interest in its use. 88% of the house staff and 64.7% of the faculty believed that the EHR increased availability of medical records, eased the determination of the treating physician, increased the ability to communicate with other physicians, increased the legibility of documentation, and eased access to laboratory results. A majority of house staff physicians believed that the EHR made workflow more efficient, reduced duplicate or unnecessary testing, saved time documenting care, and reduced patient care errors. Majority of the faculty shared their view on these questionnaire items. System speed and lack of computers were considered to be the greatest barrier by both groups.
Joseph K. Rotich et al. [2004] [17]	Primary care	Time series	Before and after implementation	Time measurement	Evaluation of the impact of introducing CPR on time of healthcare delivery within the rural health centre	The findings of this study show that the Mosoriot Medical Record System (MMRC) clearly changed the flow of healthcare in the Mosoriot Rural Health Center (MRHC). A substantial decrease in the time of patient interaction with healthcare provider was observed. The using of the system showed a clear reduction of 10 minutes (from 41 to 31 minutes) in each visit for the patients, i.e. patients who were noticed to spend less time waiting. For the healthcare providers (nurses and clinical officers) the time–motion reduction was also observed. They spent less time with patients and other staff and had as a result, more time for personal activities. For the nurses and clerks, however, it showed more time spent in registration but less time for writing reports (3% vs. 18%). Similarly there was an increase in the time for searching the information through the system (3% vs. 0, 5%). Overall, in this study, it was agreed that a simple, inexpensive, and effective electronic medical record system could be established in a developing country with poor resource; the benefits of which will be realised in the long run in terms of finances and there will be better health services served to the people.

Drik Stengel et al. [2004] [18]	Hospital	Randomized controlled trial	After implementation	Data obtained from patient medical records –Archived economic records assessed by expert observers	To determine whether the introduction handheld computer-based documentation could improve both the quantitative and qualitative aspects of medical records	From this study, it was found that the introduction of a handheld computer into daily routines increased the number of diagnosis recorded and also it improved the overall quality of the patient records. The study demonstrated that the ratings on all three investigated aspects of documentation quality were better with the electronic device than with conventional hand written documentation. The time required for handheld computer documentation was also found to be significantly decreased. It was also noticed, however, that the difference in the number of diagnoses was slightly balance by the accompanying load of redundant items which was said to be significantly in favour of the experimental handheld documentation system. The conclusion based on the study clearly affirms the practicability, accurateness, and accessibility of the documentation as compared to the traditional methods.
Likourezos A et al. [2004] [19]	Hospital	Survey	After implementation	–Questionnaire completed by 23 physicians, and 21 nurses	To measure clinicians' computer background and experience, satisfaction with, perception of, and concerns about an EMR in emergency department (ED)	The findings of study show that all clinicians were known with computer and also had used computer before than the new system is installed. Most of the physicians were familiar with the Internet as they used every day. All clinicians were trained and use the emergency department (ED) EMR. Eighty-seven percent of physicians and 85.7% of nurses use EMR every day. The similar percentage has access to the EMR from any place in the clinical setting. Easy to enter data, access data, read data on the screen were found to be facilitated by the EMR reported by clinicians. Most nurses but not physicians perceive that patient information is more confidential with EMR than with paper record. A higher percentage of nurses than physicians perceive that an EMR will eliminate paperwork and will reduce the risk of errors. A majorities of physicians and nurses report that the EMR will: not improve the quality of medical care received by the patients, not make patient care less expensive, not decrease patient waiting time, not decrease the number of ED visits, not decrease the crowding in the ED.
Rainu Kaushal et al. [2004] [23]	All domains	Survey	Before implementation	–Interview with expert panel (10 people) –Economic data obtained	To estimate the costs of an NHIN (National health information network)	The findings show that IT is an important tool used to improve the safety and efficiency of the U.S. healthcare system, but its adaptation was

Table 2 (continued)

Authors	Domain	Study design	Time of evaluation	Source of evidence	Aim of studies	Finding
				from published cost estimates		considered to remain limited largely because of a lack of aligned financial incentives and national standards. The estimate for the implementation of the National Health Information Network was regarded to be expensive. It was estimated that NHIN will cost about $156 billion capital costs and approximately 2 years time is required for real growth in the U.S healthcare costs. It was recognized that benefits from investments gained substantially both in terms of money and quality. The data obtained from the study suggested that IT could decrease costs of healthcare. At the same time, IT could improve quality of care and work performance. The study also showed that by investing in different types of clinical information systems and the providers of healthcare, it will likely to maximize the investment.
Claudia Pagliari et al. [2004] [20]	Primary hospital	Survey	After implementation	Interview with stakeholders, questionnaire to project teams and clinical users	To assess the development of the Scottish National electronic clinical communications system after implementation	The study indicates difficulties while attempting to implement a technical and behavioural change intervention. More general improvements in human and technology capability were found to be facilitated by the program. The program was perceived to have facilitated aspects like human infrastructure and stimulated joint working among stakeholder groups. The study also shows that the implementation of the system was the most successful, and electronic outpatient booking the least successful during the study.
Analia Baum et al. [2004] [21]	Hospital	Survey	After implementation	Questionnaire to 150 administrative staff, doctors, and nurses	To evaluate the impact of the implementation of a new model of helpdesk and technical support in HIS users at the hospital	The study shows a positive attitude of the users towards the implementation of HIS. A greater frequency of positive responses by the doctors than any other group was observed. The administrative staff and nurses were satisfied concerning the accessibility through the internet. Doctors showed more satisfaction higher than the nurses. Regarding the analysis of the understanding of the helpdesk, all three groups of users showed their satisfaction, although the response from the nurses was found to be less satisfactory. As a result of the study of the response time given to the users' requests, the three groups again affirmed the success of the

						system. There was with a greater response from the doctors who found HIS to be a tool with fast accessibility and availability 24 hours. The use of software, to know the requirement and to measure the response time, contributed to improving the systems image on the part of the users. It was found that response time affects both nurses and doctors satisfaction and is a condition that is to be improved.
Laura Zurita et al. [2004] [29]	Hospital	Survey	After implementation	–Interview with 12 patients –Direct observation of daily routines	To provide information about patient values and communication that will be useful in the design of a more patient friendly health record system.	The results of this research underlie the general societal tendencies of the users acceptance of the use of new technology. However, it was also observed that the users were very enthusiastic on protecting their privacy. The use of EHR is perceived to protect errors, provide more effective health systems and give better service as well as allow the health provider to have easier access to the information. The ease of accessibility of information was also expected and the study shows that the expectations were met, as 94% gained access to the system through the intranet and the rest (6%) accessed it via telephone. The intranet (helpdesk) was found to be useful for the medical groups. All users also showed satisfaction about the response time. Users' attitude was found to be positive towards the change.
Emans Evangel Joel Raja et al. [2004] [24]	Hospital	Survey	After implementation	–Structured Questionnaire distributed to 120 nurses	To Assess Computer knowledge, attitudes toward CPR, and related skills among nurses	The findings show an overall positive attitude towards computer utilization by the patients. The results of this study show that the majority of the nurses (75%) had good computer knowledge and 20.8% of them had good computer knowledge in a clinical care setting. Half of the nurses had average computer skills. The study, however, shows no relationship between computer knowledge and computer attitude and skills among nurses. Computer training types did not seem to affect nurses' computer knowledge. Attitude towards computer use was found to be independent of sex, age, nurse's experiences, professional qualifications, and monthly family income on computer usage.
Jonathan C. Hobson et al. [2005] [22]	Hospital	Cohort	Before and after implementation	Data extracted from medical hand written notes and computer data	To evaluate whether or not the use of a computerized Microsoft Word template would increase the accuracy of clinical notes	The findings of this study reveal that computerized notes were more accurate and easier to put in. The results of the study show that before implementing

Table 2 (continued)

Authors	Domain	Study design	Time of evaluation	Source of evidence	Aim of studies	Finding
						a new system, the accuracy of handwritten notes did not meet the predefined standard set. The initial study found that important demographic data were missing from ordinary handwritten notes. After implementing the notes were found to be accurate in more than 90% of the cases. The forms used to enter data were adopted easily. Calendar data entries were inserted automatically to enable easier and more accurate details. It was concluded that computerized notes should be introduced in clinics dealing with urgent referrals.
George W. Odhiambo-Otieno et al. [2005] [58]	Primary care	Survey	After implementation	–Interview with system designer's operators, users –Day-to-day observation of the operations of the system –Review of relevant literature	To evaluate the extent of which existing information systems have supported the operational management of health services at the district level in Kenya.	The authors conclude that District Health Management Information System (DHMIS) were not supportive of the District Health System (DHS) Manager's strategy and operational management function. There was a marked difference in the focus of healthcare workers and DHMIS staff. The health workers were found to complain about the quality of information produced. On the other hand, the DHMIS staffs were reported to complain about the inadequate supplies of basic resources necessary for effective operation of the system. A lack of integration was noticed in the information system studied; they were disjointed with no effective central control or coordination to ensure that the information could be made available whenever and wherever. The variation in collected data also made it impossible to allow comparison in terms of performance among DHSs. The results also revealed that there were some inadequacies of personnel, equipment, working space, storage space, trained staff, and management support. The information produced, as a result, was less accurate, untimely, lacking confidentiality, and incomplete.
Clayton P.D et al. [2005] [25]	Primary care	Survey	Before and after implementation	Data obtained from patient medical records	To discuss the benefits of using EHR and measure physician productivity before and after implementation of the EHR.	The findings of this study show that currently, of 472 employed physicians, 321 (68%) routinely enter some data directly into the EHR without coercion. Twenty-five percent (80/321) of the physicians use voice recognition for some data

						entry. Twelve of 95 ambulatory clinics have voluntarily adopted measures to eliminate paper charts. Of the 212 physicians who entered data in 2004, sixty-nine physicians (22%) increased their level of data entry, while 12 (6%) decreased. In this study it was found that the average productivity increased over the duration of the evaluation period. Most of the survey participants reported that information retrieval time was better with the EHR pilot system than their previous system and also nearly all of the providers believed that they provided better care for their patients by using the EHR and also respondents did not want to return to their previous system. Staff productivity improved significantly. Reported benefits of EHR implementation included improved intraoffice communication, decreased transcriptions costs, perceived improved quality of patient care, and improved record accessibility.
Lisa Pizziferri et al. [2005] [65]	Primary care	Time series	Before and after implementation	–Questionnaire completed by 23 physicians –Time motion Observation of physician activity	–Effect of the EHR on the physician's overall time in clinical sessions –Evaluation of physician's perceptions regarding the EHR	The results of this study show that the overall time spent per patient during clinical sessions decreased with the new system. A majority of physicians believed EHR use results in quality improvement. The results were categorized into two types: direct patient care and indirect patient care. There was no significant change in direct patient care, for example, the time spent in activities such as the time spent in examining the patient. The physician believed that the input of the new system on communication, access, efficiency, workload, and quality of care indicated that the new system resulted in an improvement in many domains. The only item showing a lower rating than average was the new system's impact on workload.
Mandi Whyte et al. [2005] [26]	Hospital	Survey	After implementation	Data obtained from patient medical records	To assess the quality of record keeping by nurses in a paediatric ward	It was found from the study that the computerized records are better for record keeping in the context of child protection, as a large amount of information is stored whenever the nurses log on. However, none of the records that were audited met the predetermined standard. The audit also indicated that both the two types of record keeping in two wards [High Dependency Unit (HDU) and Paediatric Intensive Care Unit (PICU)] had their faults. Training and education issues were found to

Table 2 (continued)

Authors	Domain	Study design	Time of evaluation	Source of evidence	Aim of studies	Finding
						be the basic reason behind the substandard results achieved by the use of the two systems. It was concluded that nursing training programs must comprise of such IT training too, and the results revealed that in the PICU, 40% of the patients did not access to their previous data.
Tim Scott et al. [2005] [59]	Primary care and hospital	Cohort	Before and after implementation	Semi structure interviews with senior clinicians, managers, project team members	To examine users' attitudes towards implementation of an EMR System	The findings of this study show that the adoption of the electronic medical record system was flawed and detached from the local environment showing disapproval of the implementation. Four major processes were identified in the implementation of EMR: selection, design and early testing, adaptation for widespread use, and adaptation of the organization to the new electronic medical records. Regarding the selection of the electronic medical record system, only one respondent expressed approval of the system choice, the rest found it problematic and reported dissatisfaction with the choice. The resistance observed towards the design and testing were thought to be due to inadequate early testing, substantial software problems, and inadequate IT knowledge. Difficulties were also noticed regarding the adoption of the electronic medical records due to differences over priorities of the users and due to software problems itself. The results also showed that the system reduced clinical productivity due to extra work involving processing laboratory result reports, entry's orders and navigating through the system.
Maria Bryson et al. [2005] [66]	All domain	Survey	After implementation	Questionnaire completed by 2020 nurses, midwives and health visitors workers (Online survey)	To investigate the nurses perception, knowledge and expectations of the National Health system's IT program	Poor access and inadequate knowledge of the plans in the National Health Service (NHS) was observed as a result of this study. The survey suggested that the nursing staffs were not fully aware of the current IT plans. However, 51% of the nurses affirmed the significant improvement brought by the integrated electronic healthcare record system in clinical care. No high level of enthusiasm as predicted was observed. Lack of confidence in using advanced information technology compounded with the lack of training and no

						involvement of the nurses in the change process were found to be the reasons behind the negative responses. For future developments, it was expected that early and regular involvement of potential users would be made possible. It was demonstrated that the nurses would be able to share decision making with clients using credible, timely, and accurate information.
Wilcox A et al [2005] [27]	Primary care	Retrospective cohort study, Survey	Before and after implementation	–Interview with 7 physicians –Tracking of medical record	To analyze the usage of summary worksheets, and their impact on physician performance.	This study shows that four physicians for every patient seen use the worksheet, and three of them stated they like it. Two identified how they use it to track either vital signs or laboratory results for their patients. One indicated he only used it sometimes, but also stated his intention to use it more. One physician said he reviews every field, while other physicians use it either for following disease-specific lab values or for reviewing medications and trending blood pressure and weight. One physician who indicated limited use said, "He does review the reminders specifically". Also the finding of this study indicated that usage has grown from a few hundred to over 25,000 unique patients per month during a 2-year period. The findings shows also diabetic patients for whom the worksheet is accessed are significantly more likely to be in compliance with accepted testing regimens for glycosolated hemoglobin.
K Mäkelä et al. [2005] [28]	Primary care	Survey	After implementation	Questionnaire to healthcare professional in 15 healthcare center	To evaluate how well EPR systems meet the needs of physicians and other healthcare professionals and to determine if there are any significant differences between EPR systems.	The findings show that despite a wide use of EPR systems in healthcare centres, those electronic databases could not yet compete in all aspects with conventional paper-based records. The fact is a reflection of the difficulty of structuring clinical data to make them easily accessible while still retaining a simple and user-friendly method to input the information for 73% of the cases, all of the information requested was made available in the EPR. No significant correlation was observed between the amount of patients for whom all information was available in the EPR and the duration for which the EPR systems had been in use. A significant difference between the type of EPR system and the percentage of patients for whom all the information was available through the EPR was demonstrated throughout the study.

Table 3 Telemedicine evaluation studies

Authors	Domain	Study design	Time of evaluation	Source of evidence	Aim of study	Finding
B. Larcheri et al. [2003] [35]	Hospital	Survey	Before and after implementation	Questionnaire completed by 59 physicians and 63 nurses (open and closed response question)	To explore user satisfaction with the new system after 6 months of experimentation	The findings of this study show that there was an overall positive attitude towards the system. A significant difference was noticed between the user opinion before and after the use of the system, thus we might conclude that the user satisfaction was generally high. A qualitative analysis showed that 86% of physician users felt that the teleconsultation was useful as it offered direct communication with the colleagues. The average of consultation time for the equivalent outpatient clinic in the same hospital for the same consultant was 15 minutes. In addition, having diagnostic information allows patients to be screened and up to 50% can be eliminated as not requesting the hospital investigation. It was expected that a technology-based approach could reduce the number of outpatient clinics by 75%, reduce the consultation time and by making the full information available, ensure that each consultation is effective.
Thomas L. et al. [2003] [39]	Home and primary care	Control trial and survey	After implementation	–Questionnaire completed by 147 students (consultant survey), 94 school nurse evaluation, 77 student evaluations, 51 parents evaluation –Economic records existence in the centers	To evaluate the quality and cost effectiveness of health care provided in urban and rural elementary school-based telehealth centers	The findings of this study show that provider, nurse, child, and parent satisfaction all were high. The providers' and nurses' decision confidence scores ranged from a low of 4 to a high of 4.8 on a 5-point scale. The high mean scores on the decision confidence scales indicated that the telehealth protocols speeded the time between diagnosis and start of treatment and helped with the nurses' decision about the disposition when the child's problem was outside of a standard protocol. The students were also positive about the interaction with the physician or the nurse practitioner average family savings per encounter were 3.4 hours of work time ($43) and $177 in emergency department or $54 in physician costs. Including travel, savings for families ranged from $101 to $224 per encounter.
Lynne Bladwin et al. [2003] [40]	Primary care	Cohort	Before and after implementation	–Time measurement –Data obtained from hospital records	To measure the effect of telemedicine on consultation time	The results of this study show that with the use of telemedicine; the number of registered outpatients in clinics decreased. The duration of the consultation time was reduced from 23 to 10

						minutes because diagnostic information was being sent in advance and in the consultation time, the users discuss the management of the disease. In other words consultation changed from diagnosis to management. With diagnostic information, patients can be screened and about half of them can be considered to be without any need of hospital investigation. Moreover, according to the results of this study telemedicine could reduce the number of outpatient clinics by 75% as well as reduce the duration of the consultation.
Finkelstein J et al [2003] [41]	Hospital and Home care	Survey	After implementation	–Questionnaire completed by 41 patients –Interview with 41 patients	To assess user acceptance of the home automated telemanagement (HAT) system	The findings show that in the pretesting phase at hospital, patients demonstrated a high level of acceptance of user interface. 90% of the patients stated no difficulties in using the system and 93% of the patients claimed they would use the system at home and advise others the system. The patients named saving time by reducing number of visits and getting results on time, and the possibility of having more comprehensive disease management as high utility of the HAT system.At the pilot testing after eight weeks of using HAT at home showed statistically significant improvement in disease-specific quality of life dimensions of general satisfaction, self efficacy, distress, and home hassles. And also the study showed significant improvement in patient satisfaction with treatment process and high acceptance of the HAT system.
Michael J. Breslow et al. [2004] [30]	Hospital	Cohort	Before and after implementation	Data collected from patients medical records	To measure the effects of telemedicine on clinical and economic outcomes in a multi site intensive care unit	The results of this study demonstrate improved clinical outcomes and financial performance. Patient mortality rates for both the ICU stay and hospitalization were lower (9.4% vs. 12.9%) when remote intensive management supplemented routine care. The average length of stay (LOS) in ICU during the supplemental care period was lower (3.63 days vs. 4.35 days). There was no change in the hospital's LOS costs were found to be reduced too, as a result of both a reduction in LOS and a decrease in the daily costs of ICU care. In addition, the reduction in ICU's LOS created new capacity

Table 3 (continued)

Authors	Domain	Study design	Time of evaluation	Source of evidence	Aim of study	Finding
						that enabled additional patients to be cared for in the two ICUs.
Marilynne A et al. [2004] [67]	Home care	Survey	After implementation	Focus groups with 9 clients and 13 nurses Interviews with 9 physicians and 9 managers	To assess the readiness of stakeholders to adopt telehomecare services for adult diabetic	The findings of this study show differences in stakeholders' conceptions of technology, including common themes among clients, providers, and organizations. Nurses, physicians, and managers shared two subjects: one related to the benefits of increased system access, particularly for rural clients and those with mobility limitations and also with respect to increased acuity and numbers of home care clients seeking services, nurses and clients shared practical concerns about the mechanics of telemedicine including system failure and ease of use. Nurses focused on disease management and support. Managers and physicians focused on overall ethics, system structured, system evaluation, and sustainability.
Kaufman D. R. et al. [2004] [68]	Home care	Cognitive walkthrough (usability testing)	After implementation	Filed usability testing in 25 subjects' home: a4 subjects in New York City and 11 in Upstate New York	To identify barriers to effective home Telemedicine use (IDEATel)	The findings of this study show that there is a range of both cognitive and noncognitive barriers that were unanticipated by the cognitive walkthrough analysis. The evaluation included a cognitive walkthrough analysis to characterize task complexity and identify potential problems as well as field usability testing in patients' homes. The study revealed dimensions of the interface that impeded optimal access to system resources. It was found significant obstacles corresponding to perceptual-motoric skills, mental models of the system, and health literacy.
Wong Y.K et al [2005] [44]	Home care	Clinical trials	After implementation	–Questionnaire completed by 22 patients.–Secondary outcome measures by medical equipment to assess patient outcomes	To explore the feasibility and efficacy of an exercise program for elderly people with knee pain conducted via videoconferencing	The findings of the study show that there were significant improvements in the primary outcome measures. Significant improvements were recorded in all secondary outcomes except range of motion of the knee. An increase of strength of 50% and 46% (Po0.001) was found in the right and left quadriceps, respectively. A 21% reduction in the time taken to complete the TUGT (timed up-and-go test) was observed. There was also significant improvement in the

						knowledge test. Over 80% of the subjects answered all the questions correctly, with an average improvement of three marks in the final evaluation. Over 80% of the elderly subjects who joined the program agreed or strongly agreed about all aspects of using videoconferencing. Most of them felt that the system was user-friendly and convenient.
Bratan T et al [2005] [36]	Home care	Clinical trials	After implementation	Interview with two physicians, 4 managers, 1 career and 1 nurse	To determine the feasibility and acceptability of home monitoring	The findings of the study show that data transmission was found to be unreliable on occasions and was improved by extending the wireless network in the homes. Data access and presentation were considered acceptable, although suggestions for minor changes were made. No discernible impact on disease management, diagnosis or care was observed as a result of the monitoring. Interviewees noted several potential benefits. Some key advantages from interviewees' point of view that were mentioned were: facilitates better communication with the general practitioner; enables early detection of deteriorations; can provide a continuous picture of patients' health; the equipment was easy to use. The monitoring was found to be generally acceptable and feasibility was considered to have been largely proven.
Mair F.S et al [2005] [37]	Home care	Randomized controlled trial	After implementation	Questionnaire completed by 22 patients and 14 nurses	To explore patient and provider perspectives on home telecare	The results of this study show that there are significant differences in perception between patients and providers with regard to telecare encounters across all the domains addressed. Patients demonstrated more positive views of the telecare encounters than providers. The providers were more concerned about the negative effects of telecare consultations on communication. With regard to the accuracy of assessment of a patient's medical problems, the patients believed that nurses could understand their problems quite well when using the telecare system, while in contrast the nurses were far less confident about this aspect of the telecare encounters. The preliminary data obtained in the present study identify a marked difference of opinion between patients and service providers about the utility and acceptability of the home telecare consultations.

Table 3 (continued)

Authors	Domain	Study design	Time of evaluation	Source of evidence	Aim of study	Finding
S Scalvini et al. [2005] [31]	Home care	Cohort	After implementation	Data collected from patient medical records	To investigate the use and economic aspects of home-based telecardiology in chronic heart failure patients	The findings of the study show that there were significant reduction in hospitalization and instability in the home-based telecardiology (HBT) group relative to the usual care group. There was a reduction of 24% in the total costs after one year in the groups, which underwent telecardiology. This cost reduction was presented after one year. There was an increase in the quality of life in HBT compared to the usual-care groups (the mean for the Minnesota living Questionnaire scores were found to be 29 and 23.5respectively).
Th Vontetsianos et al. [2005] [42]	Home care	Quasi experimental	Before and after implementation	The economic data obtained from hospital records –Questionnaire to patients	–To evaluate the clinical usefulness of a telemedicine system –To estimate economic benefits of intervention	The findings show a significant improvement regarding both usefulness and economic benefits. There was a decrease in hospitalization, which declined from 37 to only 6 as a consequence of use the system. A similar decrease in emergency department visits was also observed; visits dropped from 156 to 86 after using the system. The patient knowledge about the disease and self-management were also observed to be improved. There was a significant improvement inpatient quality of life of more than 28%, while the satisfaction rate was 32% better. Empowered patients and caregivers were able to minimize symptoms, complications, and disabilities and to increase autonomy in every day living. The total costs were lower during the study than before. The reduced costs in the present study were mainly due to the reduction in hospital admission and the lower length of stay of patients.
Sian M Noble et al. [2005] [32]	Hospital	Randomized controlled trial	Before and after implementation	–Time measurement –Interview (expert panel) –The economic data obtained from hospitals records	Cost-consequences analysis of minor injury telemedicine in a peripheral emergency department	The study shows that telemedicine has the ability to reduce costs substantially only where transport costs in the absence of telemedicine is very high. The findings also revealed that unlike the previous studies, it was found to have been more costly from both NHS and patient viewpoints. The main reasons behind it were the need for specialist equipment, higher staff costs, and higher follow-up costs. The time taken by the

						two consultations was considerably longer than for general physician consultation. It was concluded that the procedural changes may be required if telemedicine was to be put into practice (e.g. the need to triage telemedicine patients at the main hospital). It would affect both nurses and general physicians, but it is too early to predict the effects.
A Gary Linassi et al. [2005] [38]	Hospital	Survey	After implementation	Questionnaire (open/close ended questions) to 15 patients	To assess user (patient) satisfaction with telemedicine	From the result of the study, it was observed that telemedicine provides significant advantages over more traditional methods of amputee evaluation and care. Overall, the patients surveyed were satisfied with the organizational structure. Telemedicine seemed to represent a cost-effective, practical solution. It is acceptable to patients and provides a reliable assessment of the amputee. Approximately 97% of the responses were in the good to excellent range showing great user satisfaction. However, concerns were raised about ease of access to local telemedicine sites, connection waiting times and lack of familiarity with telemedicine technology. Minor difficulties related to technical aspects were observed. However, it was suggested that future developments might include more comprehensive evaluations and treatment services in the community.
D David Persaud et al. [2005] [33]	Primary care	Survey	Before and after implementation	The economic data extracted from expense report –Questionnaire (open ended) to 215 patient	To examine the cost of Telehealth from a societal perspective	The findings of this study show that the societal cost of an average Telehealth consultation was significantly higher than the cost of face-to-face consultation, even though from the perspective of the patient Telehealth services were cheaper. However, it was also observed that from a societal perspective, the overall cost of providing Telehealth was higher than providing face-to-face services. For the majority of the FC of Telehealth the large start-up capital costs account was noted to be more costly per consultation.
Eric Dillon et al. [2005] [34]	Primary care	Cohort	After implementation	–Data obtained from projects reports Interview	To evaluate costs of the Telehealth project in Australia	The authors conclude that the Western Australia Telehealth project achieved its objectives that were significant clinical utilization, educational and training support, and improved information access. However, it was found that not all clinical Telehealth projects provided significant cost

Table 3 (continued)

Authors	Domain	Study design	Time of evaluation	Source of evidence	Aim of study	Finding
						savings to the health department. Some programs represented a net cost to the health department and the savings offered by some others were only modest. However, most programmes offered significant quantitative benefits and other longer term benefits than cost savings alone. Clinical use grew by 30% of all Telehealth activity. Educational use was increased by 40% and management use found to grow by 30 %. The study also demonstrated that the average overhead cost of each Telehealth event was $AU192 which compared favourably with the average cost per trip of $A279. It was also observed that the coordinators were critical of the implementation of individual projects and played a significant role in the overall success of the projects.
Brian J et al. [2005] [43]	Hospital and Home Care	Retrospective record review	After implementation	Review of 49 outpatient records	To compare specific treatment and outcome variables between mental health care via videoconferencing to care provided in person	The findings of this study show that one group was seen via video conferencing (telemental health care [TMHC]) while a second group was seen face-to-face care (FTFC) and served as a control group showed that the Global Assessment of Functioning was significantly more improved for the TMHC group. Mean change in Global Assessment of Functioning for TMHC (15.3) was significantly more than mean change for FTFC (8.4). There were no significant differences between the groups in the number of laboratories or studies ordered, selected mental status elements, self-help recommendations made, or number of patients prescribed two or more psychotropic medications. The rate of full compliance with the medication plan and follow-up appointments was significantly better for TMHC. The finding of study also showed that Providers using TMHC told more patients to return for follow-up appointments in 30 days.

Table 4 DSS evaluation studies

Authors	System	Domain	Study design	Time of evaluation	Source of evidence	Aim of study	Finding
Short D et al [2003] [50]	CDSS	Primary care	Survey	Before and after implementation	Questionnaire and interview with 15 General practitioner	To develop and evaluate in primary care a computerized decision support system for the management of stroke patients	The findings show that practitioners were very positive for the CDSS to address uncertainty among GPs. Practitioners stated several potential benefits of the system, including helping them to improve GP–patient dialogue and reinforcing their recommendation message to patients, the applicability and acceptability of incorporating the system into a primary care consultation. The system was found easier to use and to navigate. The time to access the system was seen as a positive factor. Limitations to applicability of the system were identified such as practitioners needing basic information technology (IT) skills and both GPs and patients requiring an understanding of simple risk concepts are necessary. Quantitative results further suggested that the system made decision making easier, improved feelings of being supported, improved the quality of decision making and increased satisfaction.
Cornelia M et al [2003] [51]	CDSS	Hospital	Control trial	After implementation	Clinical trial on 52 patients who assigned to intervention or control condition Questionnaire completed by those patients	–To evaluate preliminary effects of a computerized support system on congruence between patients' reported symptoms –To investigate the system's ease of use, time requirements, and patient satisfaction.	The findings of the study reveal that there were no significant differences in numbers of reported symptoms in the intervention and control groups. There were large variations in patients' reports of frequency, severity, degree of bother of symptoms, and importance. Also the study shows that while patients in both groups were equivalent at baseline in symptom characteristics, there were significantly greater congruence between patients' reported symptoms and those addressed by their clinicians in the

Table 4 (continued)

Authors	System	Domain	Study design	Time of evaluation	Source of evidence	Aim of study	Finding
							experimental group. The system scored high on ease of use. There were no significant group differences in patient satisfaction.
Beuscart-zephir M. C et al [2004] [45]	CPOE	Hospital	Survey	After implementation	Semi structured and structured interviews of physicians and nurses Observation on users' interactions with patient records Document analysis	To study of CPOE's medication administration functions with focus impact on physician–nurse cooperation.	The findings of the study reveal that the nurse gets the medication orders on her care plan and medication administration record. When the order seems unclear or difficult to administer, she may ask the physician, if he is available. On-site observations in the paper-documented situation suggested that the doctors are not interested and don't feel committed with the exact planning of drug administration, which they ordinarily leave to the nurses. The comparison of cooperation models in both situation shows that users tend to adopt a distributed decision making paradigm in the paper-based situation, while the CPOE system supports a centralized decision making process. The usability assessment uncovered usability problems for the entry of medication administration time scheduling by the physician and revealed that the information can be ambiguous for the nurse.
Joan S. Ash et al. [2004] [69]	CPOE	Hospital	Survey	After implementation	–Semi structured interview with house staff (physicians, nurses, pharmacists, administrators, information technology staff) accompany with observation	To identify success factors concerning the implementation of CPOE	The findings of the study reveal that the direct entry of medical orders by the healthcare decision maker and its other users increased year by year during the 5-year study. It was also noted that CPOE is perceived to reduce medical errors. The study has produced detailed descriptions of factors related to CPOE's success such as (1) computer technology principles (which include: temporal concerns;

							technology and meeting information needs); multidimensional integration; and costs. (2) Personal principles: value to users, training, and support. (3) Organizational principles such as collaborative project management; terms, concept; improvement through evaluation). (4) Environmental issues provided the motivation and context for implementing such system. However, good training and support were defined as the prerequisites for better results.
Jos Aarts et al. [2004] [60]	CPOE	Hospital	Survey	After implementation	–Unstructured interview with 25 staff members –Observing the system in use	To study the Interrelationship of technical and social elements and how CPOE fit into medical work practices	The findings of this study were divided into two categories: i.e. socio and techno. The societal aspects were prominent in the experience of the administrative personal related to the system in the hospital and their attitude towards it. It was feared that greater amounts of time and cost would be required in the implementation process. This study also shows that the implementation of CPOE in two Dutch hospitals proved to be very much problematic. In one hospital CPOE never became functional, and in the other, CPOE was only used by the nursing and administrative staff. To a large extent socio-technical issues influenced the implementation, such as the existence of local infrastructures and working arrangements. These are not easily changed as a result of new technologies. Researchers suggested that introducing new technologies that influence medical work practices and organizational arrangements should be carefully planned for measurement of organizational impact to make it easier and accurate.
Choi S.S et al [2004] [57]	CPOE	Hospital	Survey	Before and after implementation	–Computer and paper based documents comparison –Interview with a nurse	To evaluation of a web-based nurse order entry system for tuberculosis patients in Peru	In this study it was found that there is no significant difference in the control groups' outputs. The intervention group showed a significant drop in the

Table 4 (continued)

Authors	System	Domain	Study design	Time of evaluation	Source of evidence	Aim of study	Finding
							error rate after the same time interval. Also in this study it was found that the nurses affirmed the system's usability and ease to use and simplicity and ability to view all of the information regarding a patient's medication history on one page. The web system shows a patient's entire regimen history from the initial regimen to the present. Additionally, the web system allowed the nurse to see all of the changes at one time.
Robert L. Ohsfeldt et al. [2004] [54]	CPOE	Hospital	Simulation	Before implementation	Questionnaire distributed to 74 general hospitals –The economic data obtained from expense reports	–To estimate the cost of implementing CPOE in hospitals in a rural state –To evaluate the financial implications of CPOE's nationwide implementation	The findings show a consistent pattern of greater use in urban hospitals. In addition, the extent of integration across clinical functions was found to be greater in urban hospitals. The financial results of this study showed that costs for CPOE implementation were about $1.3 million for critical access and rural hospitals, $2 million for rural referral, and $1.9 million for urban hospitals under the low cost scenario. For rural and critical access hospitals, these CPOE implementation costs would represent a substantial expansion overall. CPOE implementation would increase operating costs for rural and critical access hospitals in the absence of substantial cost savings associated with improved efficiency or improved patient safety. It was also observed that the cost impact is less dramatic but still substantial for the urban and rural referral hospitals.
Benjamin Bogugki et al. [2004] [55]	CDSS	Hospital	Quasi-experimental	Before and after implementation	Data obtained from patient medical records	To examine the impact of a computer-based reminder in addressing a drug shortage	The study shows a 55% decrease in the number of orders, thus in the post implementation period, there is an increase in the alternative medication. In addition, this study shows cost

							reduction (annual saving: $36,552) for the institution due to the implementation of the drug reminder system. Results show that CDSS is an effective tool in conserving medications during times of national drug shortages by rapidly changing prescribing practices.
William L. Galanter et al. [2004] [46]	CPOE	Hospital	Cohort	Before and after implementation	Data obtained from documentation	To measure the effects of alerts for inpatient digoxin use (with CPOE)	The findings of this study show that the alerts generally acted to improve both the speed and overall magnitude of appropriate clinician response to a clinical situation. This study shows that alerts, generated by unsafe medication, improved the safe use of digoxin. During CPOE, alerts associated with missing levels were effective. For hypokalemia and hypomagnesaemia, the alerts given during CPOE were not as effective as those given at the time of newly reported low electrolytes. During CPOE, supplementation for hypokalemia was not improved whereas supplementation for hypomagnesaemia improved in one hour. It was also observed that asynchronous alerts were successful in changing clinician behaviour, whereas synchronous were not. It was observed that the response to the alert was dependent upon both the manner in which the alert was communicated to the clinician, synchronic or asynchronous, and the clinical context of the alert.
Joan S. Ash et al. [2004] [70]	CPOE	Hospital	Cross sectional	After implementation	Questionnaire (open ended question) distributed 964 hospitals	To assess the –Availability of inpatient computerized physician order entry –The degree to which physicians are using it.	This study demonstrates that CPOE still does not employ widespread implementation across the U.S. hospitals. The results of this study show that CPOE was not available to 83.7% of the hospitals. Only 9.7% of U.S. hospitals presently have it. In approximately half of those hospitals,

Table 4 (continued)

Authors	System	Domain	Study design	Time of evaluation	Source of evidence	Aim of study	Finding
							more than 90% of physicians use CPOE and in one third of them, more than 90% of the orders are entered via CPOE. The data also showed that there is a trend towards a higher percentage of hospitals with CPOE requiring its use over the past 5 years, moving towards concomitant trends in higher participation and saturation proportions.
Rob Shulman et al. [2005] [47]	CPOE	Hospital	Cohort	Before and after implementation	Data from the medication errors recorded before and after implementation CPOE	To compare the impact of CPOE with hand written prescriptions based on the frequency, type and outcome of medication errors in ICU	Through this study it was demonstrated that the introduction of CPOE was associated with: a reduction in the proportion of medication errors (from 6.7% to 4.8%); an increase in some types of errors like dose error, omission of required drugs. It was noted that the prescriber's signature must be added. There was an improvement in the overall patient outcome score (the mean Acute Physiology And Chronic Health Evaluation—APACHE—II scores) with CPOE.
Park R.W. et al [2005] [52]	CPOE	Hospital	Survey	After implementation	–Questionnaire completed by directors of hospital information systems in 122 hospitals (30 teaching hospitals and 92 general hospitals)	To determine the availability of CPOE and EMR systems in teaching and general hospitals in the republic of Korea	From this study, it was found that the CPOE systems were available at all location within the hospital for all types of orders in 80.3% of all the hospitals. 93,3% of the surveyed teaching hospitals had completed CPOE systems but general hospitals did in 76,1%. 86% of hospitals replied that the use of CPOE was mandatory; 9,3% said that the hospital encouraged its use, and 4,7% said that the use was optional. 96,7% of the teaching hospitals required their physicians to order by CPOE. A majority of physicians entered most of their medical orders into CPOE system.

							Only 9% of the hospitals get available a complete EMR system. Teaching hospitals tended to demonstrate a higher percentage of EMR use than did general hospitals. With considering all forms of EMRs, including partial, two thirds of the teaching hospitals have least some form of EMRs.
Tejal K et al [2005] [53]	CPOE	Primary care	Prospective cohort study	After implementation	1879 Prescription review, 661 patient survey, and 653 chart review	To assess the rates, types, and severity of outpatient prescribing errors and understand the potential impact of computerized prescribing.	The results of the study show that of the prescriptions, 143 (7.6%) contained a prescribing error. Three errors led to preventable ADEs and 62 (43%; 3% of all prescriptions) had potential for patient injury (potential ADEs); one was potentially life threatening (2%) and 15 were serious (24%). Errors in frequency (n=77, 54%) and dose (n= 26, 18%) were common. The rates of medication errors and potential ADEs were not significantly different at basic computerized prescribing sites (4.3% vs 11.0%, P=.31; 2.6% vs 4.0%, P =.16) compared to handwritten sites. Advanced checks (including dose and frequency checking) could have prevented 95% of potential ADEs.
William L. Galanter et al. [2005] [48]	CPOE	Hospital	Cohort	Before and after implementation	Data obtained from the patient records	To evaluate the utility of alerts as well as analyze the factors that may play a role in noncompliance with alert recommendations among house staff in order to improve CDS in the future	The results of the study show that the alerts (generated by unsafe medication) were effective in decreasing the order and administration of drugs contradictions due to renal insuffiency. The likelihood of a patient receiving at least one dose of contradicted medication decreased from 89% to 47% after alert implementation, which shows a 42% reduction in administration. It was noted that this reduction was almost entirely due to the cancellation of the order after viewing the alert, which occurred in 41% of the mistakes in which an alert was given. The time of the day was not found to be significantly associated with the likelihood of alert

Table 4 (continued)

Authors	System	Domain	Study design	Time of evaluation	Source of evidence	Aim of study	Finding
							compliance. The study also revealed that compliance with the alerts was higher in male patients, was noted to increase with the duration of house staff training, and increased in patients with more severe renal dysfunction.
Ross Koppel et al. [2005] [61]	CPOE	Hospital	Survey	After implementation	–Interview with house staff and information technologists, nurses, pharmacists, and physicians –Observation (house staff, nurses and physicians)–Questionnaire to house staff	To identify the role of CPOE in facilitating prescription error risk	The findings of the study demonstrate that a widely used CPOE system facilitated 22 types of error risks. For example, fragmented CPOE displays mistakes for dosage guidelines, ignored antibiotic renewals, notices placed on paper charts rather than in the CPOE system, separation of functions that facilitate double dosing and incompatible orders, and inflexible ordering formats generating wrong orders. Three quarters of the house staff reported observing each of these error risks and indicated that they were occurring weekly or more often. It was also observed that many errors occurred frequently. It was suggested that as CPOE systems are implemented, clinician and hospitals must attend to errors that these systems cause in addition to errors that they prevent.
Jaap L. Van den brink et al. [2005] [56]	DSS	Hospital	Cohort	After implementation	–Questionnaire to patients data obtained from automated logging on system	To determine use, appreciation, and effectiveness of an information system	The results of the study show the patient used the system intensively (averaging 4–5 times a week). It was observed that the patient appreciated the system highly. 89% were noticed to advise other patients. Patient satisfaction questions scored high percentages between 91–94%. Most patients were noted to learn the system easily (with a percentage of 61%). The system detected patient problems that had not been discovered during regular outpatient visits.

Vitali Sintchenko et al. [2005] [49]	DSS	Hospital	Cohort	Before and after implementation	Data obtained from the patient records	To assess the effect of a computer-based decision support system on antibiotic use and patient outcome in a critical care unit	The results of this study suggest that the use of the DSS contributed to the reduction of patient length of stay in the ICU. The introduction of the DSS was found to have been associated with a reduction in antibiotic usage in the ICU. It was also found to have brought a change in patterns of antibiotics use in the ICU. It was also demonstrated through this study that there was difficulty with the use of the DSS among clinicians with different roles.

analysis should be used to investigate influences of the new systems on the organisation and its personnel.

In our review we found that during the period 2003–2005, most of the evaluations aimed to include issues such as the effectiveness of the systems, the quality of care, user and patient satisfaction, and the system's usability. And also the evaluation studies tended to use subjective approaches combined with quantitative studies in order to analysing cost and benefits.

Most of the studies included in this paper have used survey methodology as their research method. Some of the studies focused upon financial analysis, such as a cost and benefit or consequences approach. Some of the studies used a clinical trial or cohort study to research the systems' outputs. It is, however, important to note that it has been difficult to find generalized models and methods to evaluate IT-based applications in clinical settings that cover all aspects such as economic and inter- and intra-organizational approaches. It seems that there are no clear guidelines for evaluation studies to develop evaluations and obtain more clear and exact feedback about the implemented systems.

A key requirement for analytical work is a clear definition of what constitutes an IT-based application. Today there are different terminologies relating to similar systems. Analysis of the effects has predominantly taken place at an organizational level. However, this does not take account of the differences in the settings in which analysis is taking place.

A significant barrier to investment in IT in healthcare is the widely recognized fact that any cost saving resulting from technology changes is not always seen by the implementer, but is rather passed on to a third party. In essence, benefits appear at one site and in one budget, while a large share of the cost commitments appear at another site and in another budget. To our best knowledge, the evaluation studies performed do not include any discussion about this important issue, or how lack of incentive to adopt systems can influence the organization and its personnel.

As in other areas, such as healthcare for the elderly [62, 63], evaluation studies in general pay more attention to the technical aspects and/or direct costs of the technology in use. Further, the potential effects of the implementation of IT-based applications are identified without analysing them from an inter-organizational and economic perspective.

In addition to difficulties in quantifying the output of the use of IT in healthcare, evaluative challenges in assessing the impact of IT include isolating its impacts from others. It is difficult to find a clear relationship between IT, organizational improvements, quality of care and benefits realization.

The most common type of analytical approach used takes the form of a case study, and usually retrospective ones that try to measure the actual impact of an IT

investment or prospective assessments. The evaluations therefore suffer two main weaknesses. First, it is difficult to attribute IT investments to observed effects, because it is usually not possible to apply case-control design to the evaluative study. Second, it is difficult to generalize from the particular study to the broader context. The results of our review show that the study of the impact of IT in healthcare is currently limited. No studies have been conducted to explore the impact of IT on the system as a whole. Few organizational-level studies exist that focus explicitly upon the impact of IT in a specific sector of care. This review therefore suggests that there is an increasing need to share knowledge and find methods to evaluate the impact of investments, and in parallel with this, formulate indicators for success. It is therefore interesting to develop or extend evaluation methods that can be applied to this area, but also that have a multi-actor perspective in order to understand the effects, consequences and prerequisites that have to be achieved for the successful implementation and use of IT in healthcare.

References

1. Kaplan, B., Evaluating informatics applications—some alternative approaches: theory, social interactionism, and call for methodological pluralism. *Int. J. Med. Inform.* 64:39–56, 2001.
2. Ammenwerth, E., Brender, J., Nykanen, P., Prokosch, H. U., Rigby, M., and Talmon, J., Visions and strategies to improve evaluation of health information systems. Reflections and lessons based on the HIS-EVAL workshop in Innsbruck. *Int. J. Med. Inform.* 73:479–491, 2004.
3. Ammenwerth, E., Iller, C., and Mansmann, U., Can evaluation studies benefit from triangulation? A case study. *Int. J. Med. Inform.* 70:237–248, 2003.
4. Andersen, J. G., Aydin, C. E., and Jay, S. J., *Evaluating Healthcare Information Systems: Methods and Applications.* Thousand Oaks, CA: Sage publication, 1994.
5. Friedman, C. P., and Wyatt, J. C., *Evaluation Methods in Medical Informatics.* New York: Springer, 1996.
6. Kaplan, B., and Shaw, N. T., Future directions in evaluation research: People, organizational, and social issues. *Methods Inf. Med.* 43:215–231, 2004.
7. Phil, W., An assessment of strategies for information system evaluation: Lessons for education. *Int. J. Educ. Res.* 25:361–371, 1996.
8. Delpierre, C., Cuzin, L., Fillaux, J., Alvarez, M., Massip, P., and Lang, T., A systematic review of computer-based patient record systems and quality of care: More randomized clinical trials or a broader approach. *Int. J. Qual. Health Care*. 16:407–416, 2004.
9. Wang, S. J., Middleton, B., Bardon, C. G., Spurr, C. D., Carchidi, P. J., Kittler, A. f., Goldszar, R. C., Fairchild, D. G., Sussman, A. J., Kuperman, G. J., and Bates, D. W., A cost-benefit analysis of electronic medical records in primary care. *Am. J. Med.* 114:397–403, 2003.
10. Laerum, H., Karlsen, T. H., and Faxvaag, A., Effects of scanning and eliminating paper-based medical records on hospital physicians' clinical work practice. *J. Am. Med. Inform. Assoc.* 10:160–588, 2003.
11. Ruland, C. M., and Ravn, I. H., Usefulness and effects on costs and staff management of a nursing resource management information system. *J. Nurs. Manag.* 11:208–215, 2003.
12. Houston, T. K., Ray, M. N., Crawford, M. A., Giddens, T., and Berner, E. S., Patient perceptions of physician use of handheld computers. *AMIA Annu. Symp. Proc.* 299–303, 2003.
13. Ammenwerth, E., Mansmann, U., Iller, C., and Eichstädter, R., Factors affecting and affected by user acceptance of computer-based nursing documentation: Results of a two-year study. *J. Am. Med. Inform. Assoc.* 10:69–84, 2003.
14. Zhang, W. P., Yamauchi, K., Mizuno, S., Zhang, R., and Huang, D. M., Analysis of cost and assessment of computerized patient record systems in Japan based on questionnaire survey. *Med. Inform. Internet Med.* 29:229–238, 2004.
15. Laerum, H., Karlsen, T. H., and Faxvaag, A., Use of and attitudes to a hospital information system by medical secretaries, nurses and physicians deprived of the paper-based medical record: A case report *BMC Med. Inform. Decis. Mak.* 4:18, 2004.
16. Hier, D. B., Rothschild, A., LeMaistre, A., and Keeler, J., Differing faculty and housestaff acceptance of an electronic health record one year after implementation. *Medinfo*. 11:1300–1303, 2004.
17. Rotich, J. K., Hannan, T. J., Smith, F. E., Bii, J., Odero, W. W., Vu, N., Mamlin, B. W., Mamlin, J. J., Einterz, R. M., and Tierney, W. M., Installing and implementing a computer-based patient record system in sub-Saharan Africa: The Mosoriot Medical Record System. *Med. Inform. Internet Med.* 10:295–303, 2003.
18. Stengel, D., Bauwens, K., Walter, M., Kopfer, T., and Ekkernkamp, A., Comparison of handheld computer-assisted and conventional paper chart documentation of medical records. A randomized, controlled trial. *J. Bone Joint Surg. Am.* 86:553–560, 2004.
19. Likourezos, A., Chalfin, D. B., Murphy, D. G., Sommer, B., Darcy, K., and Davidson, S. J., Physician and nurse satisfaction with an Electronic Medical Record System. *J. Emerg. Med.* 27:419–424, 2004.
20. Pagliari, C., Gilmour, M., and Sullivan, F., Evaluating national electronic clinical communications implementation in Scotland. *Medinfo*. 11:1794, 2004.
21. Baum, A., Figar, S., Serverino, J., Assale, D., Schachner, B., Otero, P., Luna, D., and de Quiros, F. G., Assessing the impact of change in the organization of a technical support system for a health information systems (HIS). *Medinfo*. 11:1367–1370, 2004.
22. Hobson, J. C., Khemani, S., and Singh, A., Prospective audit of the quality of ENT emergency clinic notes before and after introduction of a computerized template. *J. Laryngol. Otol.* 119:264–266, 2005.
23. Kaushal, R., Blumenthal, D., Poon, E. G., Jha, A. K., Franz, C., Middleton, B., Glaser, J., Kuperman, G., Christino, M., Fernandopulle, R., Newhouse, J. P., and Bates, D. W., The costs of a national health information network. *Ann. Intern. Med.* 143:165–173, 2005.
24. Raja, E. E., Mahal, R., and Masih, V. B., An exploratory study to assess the computer knowledge, attitude and skill among nurses in healthcare setting of a selected hospital in Ludhiana, Punjab, India. *Medinfo*. 11:1304–1307, 2004.
25. Clayton, P. D., Naus, S. P., Bowes, W. A., Madsen, T. S., Wilcox, A. B., Orsmond, G., Rocha, B., Thornton, S. N., Jones, S., Jacobsen, C. A., Udall, M. R., Rhodes, M. L., Wallace, B. E., Cannon, W., Gardner, J., Huff, S. M., and Leckman, L., Physician use of electronic medical records: issues and successes with direct data entry and physician productivity. *AMIA Annu. Symp. Proc.* 141–145, 2005.
26. White, M., Computerised versus handwritten records. *Paediatr. Nurs.* 17:15–18, 2005.
27. Wilcox, A. B., Jones, S. S., Dorr, D. A., Cannon, W., Burns, L., Radican, K., Christensen, K., Brunker, C., Larsen, A., Narus, S. P., Thornton, S. N., and Clayton, P. D., Use and impact of a computer-generated patient summary worksheet for primary care. *AMIA Annu. Symp. Proc.* 824–828, 2005.

28. Makela, K., Virjo, I., Aho, J., Kalliola, P., Koivukoski, A. M., Kurunmaki, H., Kahara, M., Uusitalo, L., Valli, M., Vuotari, V., and Ylinen, S., Electronic patient record systems and the general practitioner: an evaluation study. *J. Telemed. Telecare.* 11:S2:66–68, 2005.
29. Zurita, L., and Nohr, C., Patient opinion–EHR assessment from the users perspective. *Medinfo*. 11:1333–1336, 2004.
30. Breslow, M. J., Rosenfeld, B. A., Doerfler, M., Burke, G., Yates, G., Stone, D. J., Tomaszewicz, P., Hochman, R., and Plocher, D. W., Effect of a multiple-site intensive care unit telemedicine program on clinical and economic outcomes: an alternative paradigm for intensivist staffing. *Crit. Care Med.* 32:31–38, 2004.
31. Scalvini, S., Capomolla, S., Zanelli, E., Benigno, M., Domenighini, D., Paletta, L., Glisenti, F., and Giordano, A., Effect of home-based telecardiology on chronic heart failure: Costs and outcomes. *J. Telemed. Telecare.* 11:S1:16–18, 2005.
32. Noble, S. M., Coast, J., and Benger, J. R., A cost-consequences analysis of minor injuries telemedicine. *J. Telemed. Telecare.* 11:15–19, 2005.
33. Persaud, D. D., Jreige, S., Skedgel, C., Finley, J., Sargeant, J., and Hanlon, N., An incremental cost analysis of telehealth in Nova Scotia from a societal perspective. *J. Telemed. Telecare.* 11:77–84, 2005.
34. Dillon, E., Loermans, J., Davis, D., and Xu, C., Evaluation of the westerrn Australian Department of Health telehealth project. *J. Telemed. Telecare.* 11:S2:19–S2:121, 2005.
35. Larcher, B., Arisi, E., Berloffa, F., Demichelis, F., Eccher, C., Galligioni, E., Galvagni, M., Martini, G., Sboner, A., Tomio, L., Zumiani, G., Graiff, A., and Forti, S., Analysis of user-satisfaction with the use of a teleconsultation system in oncology. *Med. Inform. Internet. Med.* 28:73–84, 2003.
36. Bratan, T., Clarke, M., Jones, R., Larkworthy, A., and Paul, R., Evaluation of the practical feasibility and acceptability of home monitoring in residential homes. *J. Telemed. Telecare.* 11 (Suppl 1):29–31, 2005.
37. Mair, F. S., Goldstein, P., May, C., Angus, R., Shiels, C., Hibbert, D., O'Connor, J., Boland, A., Roberts, C., Haycox, A., and Capewell, S., Patient and provider perspectives on home telecare: preliminary results from a randomized controlled trial. *J. Telemed. Telecare.* 11(Suppl 1):95–97, 2005.
38. Linassi, A. G., and Li Pi Shan, R., User satisfaction with a telemedicine amputee clinic in Saskatchewan. *J. Telemed. Telecare.* 11:414–418, 2005.
39. Young, T. L., and Ireson, C., Effectiveness of school-based telehealth care in urban and rural elementary schools. *Pediatrics*. 112:1088–1094, 2003.
40. Baldwin, L., Clarke, M., Hands, L., Knott, M., and Jones, R., The effect of telemedicine on consultation time. *J. Telemed. Telecare.* 9:S1:71–73, 2003.
41. Finkelstein, J., Khare, R., and Ansell, J., Feasibility and patients' acceptance of home automated telemanagement of oral anti-coagulation therapy. *Proc. AMIA Symp.* 230–234, 2003.
42. Vontetsianos, T., Giovas, P., Katsaras, T., Rigopoulou, A., Mpirmpa, G., Giaboudakis, P., Koyrelea, S., Kontopyrgias, G., and Tsoulkas, B., Telemedicine-assisted home support for patients with advanced chronic obstructive pulmonary disease: preliminary results after nine-month follow-up. *J. Telemed. Telecare.* 11: S1:86–S1:88, 2005.
43. Grady, B. J., and Melcer, T., A retrospective evaluation of TeleMental Healthcare services for remote military populations. *Telemed J E Health*. 11:551–558, 2005.
44. Wong, Y. K., Hui, E., and Woo, J., A community-based exercise programme for older persons with knee pain using telemedicine. *J. Telemed. Telecare.* 11:310–315, 2005.
45. Beuscart-Zephir, M. C., Pelayo, S., Degoulet, P., Anceaux, F., Guerlinger, S., and Meaux, J. J., A usability study of CPOE's medication administration functions: impact on physician-nurse cooperation. *Medinfo*. 11:1018–1022, 2004.
46. Galanter, W. L., Polikaitis, A., and DiDomenico, R. J., A trial of automated safety alerts for inpatient digoxin use with computerized physician order entry. *J. Am. Med. Inform. Assoc.* 11:270–277, 2004.
47. Shulman, R., Singer, M., Goldstone, J., and Bellingan, G., Medication errors: a prospective cohort study of hand-written and computerised physician order entry in the intensive care unit. *Crit. Care*. 9:R516–R521, 2005.
48. Galanter, W. L., Didomenico, R. J., and Polikaitis, A., A trial of automated decision support alerts for contraindicated medications using computerized physician order entry. *J. Am. Med. Inform. Assoc.* 12:269–274, 2005.
49. Sintchenko, V., Iredell, J. R., Gilbert, G. L., and Coiera, E., Handheld computer-based decision support reduces patient length of stay and antibiotic prescribing in critical care. *J. Am. Med. Inform. Assoc.* 12:398–402, 2005.
50. Short, D., Frischer, M., and Bashford, J., The development and evaluation of a computerised decision support system for primary care based upon 'patient profile decision analysis'. *Inform. Prim. Care*. 11:195–202, 2003.
51. Ruland, C. M., White, T., Stevens, M., Fanciullo, G., and Khilani, S. M., Effects of a computerized system to support shared decision making in symptom management of cancer patients: Preliminary results. *J. Am. Med. Inform. Assoc.* 10:573–579, 2003.
52. Park, R. W., Shin, S. S., Choi, Y. I., Ahn, J. O., and Hwang, S. C., Computerized physician order entry and electronic medical record systems in Korean teaching and general hospitals: Results of a 2004 survey. *J. Am. Med. Inform. Assoc.* 12:642–647, 2005.
53. Gandhi, T. K., Weingart, S. N., Seger, A. C., Borus, J., Burdick, E., Poon, E. G., Leape, L. L., and Bates, D. W., Outpatient prescribing errors and the impact of computerized prescribing. *J. Gen. Intern. Med.* 20:837–841, 2005.
54. Ohsfeldt, R. L., Ward, M. M., Schneider, J. E., Jaana, M., Miller, T. R., Lei, Y., and Wakefield, S., Implementation of hospital computerized physician order entry systems in a rural state: Feasibility and financial impact. *J. Am. Med. Inform. Assoc.* 12:20–27, 2005, Jan.
55. Bogucki, B., Jacobs, B. R., and Hingle, J., Computerized reminders reduce the use of medications during shortages. *J. Am. Med. Inform. Assoc.* 11:278–280, 2004.
56. Van den Brink, J. L., Moorman, P. W., de Boer, M. F., Pruyn, J. F., Verwoerd, C. D., and van emmel, J. H., Involving the patient: a prospective study on use, appreciation and effectiveness of an information system in head and neck cancer care. *Int. J. Med. Inform.* 74:839–849, 2005.
57. Choi, S. S., Jazayeri, D. G., Mitnick, C. D., Chalco, K., Bayona, J., and Fraser, H. S., Implementation and initial evaluation of a Web-based nurse order entry system for multidrug-resistant tuberculosis patients in Peru. *Medinfo*. 11:202–206, 2004.
58. Odhiambo-Otieno, G. W., Evaluation of existing district health management information systems a case study of the district health systems in Kenya. *Int. J. Med Inform.* 74:733–744, 2005.
59. Scott, J. T., Rundall, T. G., Vogt, T. M., and Hsu, J., Kaiser Permanente's experience of implementing an electronic medical record: A qualitative study. *BMJ*. 331:1313–1316, 2005.
60. Aarts, J., and Berg, M., A tale of two hospitals: a sociotechnical appraisal of the introduction of computerized physician order entry in two Dutch hospitals. *Medinfo*. 11:999–1002, 2004.
61. Koppel, R., Metlay, J. P., Cohen, A., Abaluck, B., Localio, A. R., Kimmel, S. E., and Strom, B. L., Role of computerized physician order entry systems in facilitating medication errors. *JAMA*. 293:1197–1203, 2005.
62. Vimarlund, V., and Olve, N. G., Economic analyses for ICT in elderly healthcare: Questions and challenges. *Health Informatics J.* 11:309–321, 2005.

63. Olve, N. G., Vimarlund, V., and Agerbo, M. Evaluation as multi-actor trade-off—A challenge in introducing ICT innovations in the health sector. Invited paper, *4th WSEAS International Conference on E-Activities*. Miami, Florida, USA, November 17–19, 2005.
64. Adams, W. G., Mann, A. M., and Bauchner, H., Use of an electronic medical record improves the quality of urban pediatric primary care. *Pediatrics*. 111:626–632, 2003.
65. Pizziferri, L., Kittler, A. F., Volk, L. A., Honour, M. M., Gupta, S., Wang, S., Wang, T., Lippincott, M., Li, Q., and Bates, D. W., Primary care physician time utilization before and after implementation of an electronic health record: A time-motion study. *J. Biomed. Inform.* 38:176–188, 2005.
66. Bryson, M., Tidy, N., Smith, M., and Levy, S., An online survey of nurses' perceptions, knowledge and expectations of the National Health Service modernization programme. *J. Telemed. Telecare.* 11:S1:64–66, 2005.
67. Hebert, M. A., and Korabek, B., Stakeholder readiness for telehomecare: implications for implementation. *Telemed J E Health*. 10:85–92, 2004.
68. Kaufman, D. R., Starren, J., Patel, V. L., Morin, P. C., Hilliman, C., Pevzner, J., Weinstock, R. S., Goland, R., and Shea, S. A cognitive framework for understanding barriers to the productive use of a diabetes home telemedicine system. *AMIA Annu. Symp. Proc.* 356–360, 2003.
69. Ash, J. S., Sittig, D. F., Seshadri, V., Dykstra, R. H., Carpenter, J. D., and Stavri, P. Z., Adding insight: a qualitative cross-site study of physician order entry. *Medinfo*. 11:1013–1017, 2004.
70. Ash, J. S., Gorman, P. N., Seshadri, V., and Hersh, W. R., Computerized physician order entry in U.S. hospitals: results of a 2002 survey. *J. Am. Med. Inform. Assoc.* 11:95–99, 2004.
71. Ammenwerth, E., and de Keizer, N., An inventory of evaluation studies of information technology in healthcare trends in evaluation research 1982–2002. *Methods Inf. Med.* 44:44–56, 2005.
72. Kaplan, B., Evaluating informatics applications—Clinical decision support systems literature review. *Int. J. Med. Inform.* 64:39–56, 2001.