



Review

The impact of medical informatics on patient satisfaction: A USA-based literature review

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ABSTRACT

Purpose: Patient satisfaction is increasingly recognized as an important component of quality. The expansion of health information technologies (HIT) might have an impact on patient satisfaction – either positively or negatively. We conducted a literature review to explore the impact of these technologies on patient satisfaction.

Methods: The database of PubMed was searched from inception through May 2010, using the MeSH terms “Medical Informatics” and “Patient Satisfaction”. We included all original interventional studies regardless of their study design that were published in English and were evaluating HIT impact on patient satisfaction. Studies were categorized by technology type according to the American Medical Informatics Association framework and by study design. The major outcome of interest was the HIT impact on patient satisfaction.

Results: Of 1293 citations reviewed, 56 studies met our inclusion criteria. Design of these studies included mostly randomized controlled trials (RCTs) ($n=20$, 36%), cross-sectional surveys ($n=17$, 30%), and a pre and post studies ($n=14$, 25%). Overall, 54% ($n=30$) of the studies demonstrated a positive effect of HIT on patient satisfaction, 34% ($n=19$) failed to show any effect, 11% ($n=6$) had inconclusive results, and 2% ($n=1$) revealed a negative effect. Of the 20 RCTs, 40% ($n=8$) showed a positive effect of HIT on patient satisfaction, 50% ($n=10$) failed to show any effect, and 10% (2) had inconclusive results.

Conclusions: Analysis suggested that while there is some evidence that HIT improves patient satisfaction, studies in this literature review, and in particularly RCTs, were not consistent in their findings. Although HIT may be a promising tool to improve patient satisfaction, more well-designed research studies are needed in order to get a better understanding of this domain and accordingly find new opportunities to improve quality of care.

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1. Introduction

Patient-centered outcomes are increasingly valued when measuring the effectiveness of health care delivery. Accordingly, patient-centered outcomes and patient satisfaction have gained importance in addition to more traditional clinical quality measures, and are now considered one of the six key dimensions of high-quality health care system by the Institute of Medicine [1–3]. Moreover, recent research has indicated that higher patient satisfaction is associated with improved clinical guideline adherence, lower inpatient mortality rate in addition to the fact that patients are considered good discriminators of the type of care they receive [4]. Since much of the patient satisfaction data reflect quality of care, the domains of patient satisfaction are receiving close attention from payers, providers, consumers, employers, and accrediting organizations.

Medical informatics has grown as a discipline over the past decade in parallel with the increased use of health information technology (HIT). An abundance of advances have occurred in this field with vast numbers of new technologies being used in all aspects of health care research and practice [5]. Due to these advances, tremendous amounts of medical informatics research data are being generated. Many of those studies obtain information on the efficacy, cost, safety and of course the impact of HIT on quality of care [6–11].

In many ways, the importance of medical informatics technology stems from one significant challenge, to improve and maximize the quality of care. In view of the significant association of patient satisfaction with quality of care, it is important that original research studies evaluate the impact of medical informatics technologies on patient satisfaction. However, despite the growing evidence base on medical informatics research in general, and in evaluating patients perceptions towards specific aspects of the HIT systems in particular (e.g., usability, confidentiality, patient–physician communication), there is limited information on how

medical informatics affects the overall patients satisfaction from the care they received. To address this issue, we conducted a literature review to explore how medical informatics technologies impact patient satisfaction and to determine where future research endeavors in this field might best be directed.

2. Methods

2.1. Data sources and search strategy

A comprehensive literature search was performed using the PubMed database from its inception to May 2010. Our search strategy was specific to this database and included the Medical Subject Headings (MeSH) term “Patient Satisfaction” in conjunction with the MeSH term “Medical Informatics”.

The primary aim of this review was to provide a focused assessment of the current literature describing the impact of the use of medical informatics on overall patient satisfaction. In order to focus on our primary aim, we chose to exclude other related terms such as patient expectations, patient acceptance, consumer/customer satisfaction and patient complaints. A major challenge in delineating this research agenda was choosing from the many existing definitions of medical informatics and patient satisfaction. In defining medical informatics we decided to use the American Medical Informatics Association (AMIA) definition, as this definition also provided our framework for categorizing the informatics research papers. Thus, medical informatics was defined as: “The discipline that studies and applies information management and science in the context of biomedicine and health.” Furthermore, we chose to use the description of the MeSH term, patient satisfaction, included in PubMed as this was the database used to implement our search strategy. Thus, patient satisfaction was described as: “The degree to which the individual regards the health care service or product or

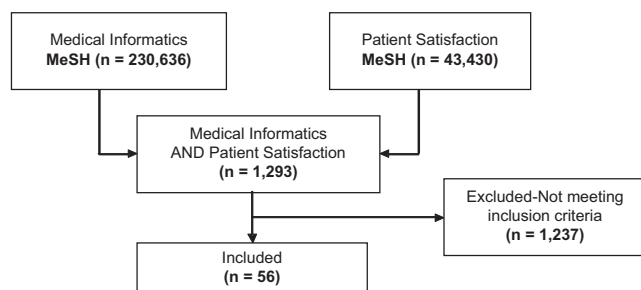


Fig. 1 – Search flow for Patient Satisfaction and Medical Informatics literature.

manner in which it is delivered by the provider as useful, effective or beneficial.”

2.2. Study selection

Three reviewers (RR, PMH and EG) individually examined all titles and abstracts. Articles were selected according to the following inclusion criteria:

- 1) Original interventional studies;
- 2) Studies that evaluate the impact of medical informatics technology on overall patient satisfaction;
- 3) Studies meeting the AMIA definition of Medical Informatics and the description of the MeSH term Patient Satisfaction in PubMed;
- 4) Articles written in the English.

Following the reviewers individual examination, the selected articles were re-examined for redundancy by the three reviewers together (RR, PMH and EG) and duplicate results were removed. Uncertainties or disagreements between the three reviewers were resolved by consensus discussion among all seven reviewers (RR, JD, PMH, EG, MAL, EZ, DW).

Systematic reviews sometimes limit their selection of papers to RCTs as the highest level of evidence [12]. However, due to the paucity of RCT level evidence in this field we chose to retrieve all original interventional studies that addressed the research question, regardless of study design.

2.3. Literature selection overview

A search of the PubMed database retrieved 230,636 articles for Medical Informatics (MeSH) and 43,430 articles for Patient Satisfaction (MeSH). Using Medical Informatics and Patient Satisfaction terms in conjunction decreased this list to 1293 results. During the screening process we rejected 1237 articles which did not meet our inclusion criteria and included 56 articles in the final analysis (Fig. 1).

2.4. Data analysis

The 56 publications meeting the inclusion criteria were obtained as full text articles and all were assessed and analyzed by the seven reviewers independently. Many potential

Table 1 – Categories of informatics research (AMIA).

Applied informatics – real world solutions for real world problems

A. Advanced technology and application infrastructure

1. Data standards and enterprise data exchange
2. System security and assurance of privacy
3. Human factors, usability, and human–computer interaction
4. Wireless applications and handheld devices
5. High-performance and large-scale computing
6. Applications of new devices and emerging hardware technologies

B. Evaluation, outcomes and management issues

1. Organizational issues and enterprise integration
2. System implementation and management issues
3. Health services research: health care outcomes and quality

C. Information, systems and knowledge resources for defined application areas

1. Care of the patient
 - a. Electronic medical records
 - b. Computer-based order entry
 - c. Clinical decision support, reference information, decision rules, and guidelines
 - d. Workflow and process improvement systems
 - e. Nursing care systems
 - f. Ambulatory care and emergency medicine
 - g. Telemedicine and clinical communication
 - h. Patient self-care, and patient–provider interaction
 - i. Disease management
2. Care of populations
 - a. Disease surveillance
 - b. Regional databases and registries
 - c. Bioterrorism surveillance and emergency response
 - d. Data warehouses and enterprise databases
3. Enhancements for education and science
 - a. Consumer health information
 - b. Education, research and administrative support systems
 - c. Library applications
4. Bioinformatics and computational biology
 - a. Genomics
 - b. Proteomics
 - c. Studies linking the genotype and phenotype
 - d. Determination of biomolecular structure
 - e. Biological structure and morphology
 - f. Neuroinformatics
 - g. Stimulation of biological systems

AMIA framework (the table) obtained from Ref. [5].

methods exist to categorize research studies in the field of medical informatics; we chose to use a framework developed by AMIA which categorizes informatics research according to real world solutions for real world problems (Table 1). Each study was assigned to a category from this framework that represents a different ongoing area of inquiry with potential challenges and opportunities for medical informatics research and application [5]. The framework allowed us to describe and differentiate various technologies and applications that were mentioned in the papers by formal categories of informatics research. In cases where more than one category could be assigned to a specific technology, we assigned the paper to the category which best described the main application of the

Table 2 – Summary of studies dealing with advanced technology and application infrastructure.

AMIA major category	AMIA sub-category	Sub-category title	Study design	Patient satisfaction major/minor	Patient satisfaction outcome
A [n = 5]	A3 [n = 4]	Human factors, usability, and human–computer interaction	RCT [15] Pre–Post [13,14] Survey [16]	Major [15,16] Minor [13,14]	Improved [14] Negative effect [13] Unchanged [15,16] Improved [17]
	A4 [n = 1]	Wireless applications and handheld devices	RCT [17]	Minor [17]	Improved [17]

For more information on AMIA categories refer to Table 1. [n] = number of papers in particular category.

medical informatics technology. We achieved final classification of the studies by consensus agreement.

The studies were also classified according to their design (RCT, non-randomized controlled trials, pre–post, cross-sectional and survey) and divided into “minor” or “major” groups. Articles classified as “major” had patient satisfaction as a primary outcome measure when evaluating the technology, whereas articles were considered “minor” for this review if the technology evaluated had several different outcome measures, where one of them was patient satisfaction. In addition, the papers were divided according to the impact of the technology on the overall patient satisfaction (improve, mixed, unchanged, negative effect). We reported improvement in patient satisfaction when a statistically significant difference between the intervention group and the control group was found (P value < 0.05). Finally, we described specifically in greater detail the RCT studies in the appendix. The appendix includes information about the author, year of publication, study participants, target audience, the intervention, primary outcome, type of satisfaction measurement tool as well as key results and conclusion.

3. Results

Of the 56 original interventional studies that met the inclusion criteria, 20 were designed as RCT studies, 17 survey, 14 pre and post, 4 non-randomized and 1 cross sectional study. Twenty-seven papers (48%) were classified as major and 29 (52%) as minor. Thirty studies (54%) demonstrated a positive effect of technology on patient satisfaction, 19 (34%) failed to show any effect, 6 (11%) had inconclusive results, and only 1 paper (2%) revealed a negative effect on patient satisfaction.

All 56 papers were classified and assigned by category according to the AMIA framework. The classifications of the papers by categories are described below.

3.1. AMIA category A: advanced technology and application infrastructure

There were five papers in category A (Table 2). Four papers [13–16] were classified as sub-category A3 “human factors, usability, and human–computer interaction” and one paper [17] as sub-category A4 “Wireless applications and handheld devices”. Only one paper out of the four in sub-category A3 was designed as an RCT study. This study, which dealt with introducing computerized patient records in primary care

clinics, showed no effect on patient satisfaction [15]. The paper that was classified as sub-category A4 and was also designed as an RCT study, evaluated the personal digital assistant system [17]. This technology which was used by residents and attending physicians in the emergency department led to an improvement in patient satisfaction. Of the sub-category A3 studies, one evaluated the effect of point of care technology on the quality of patient care and showed a negative effect on patient satisfaction [13].

3.2. AMIA category C: information, systems and knowledge resources for defined application areas

The majority of the papers (51 papers) were classified as category C. Fifty papers as sub-category C1 “Care of the patient” and one paper as sub-category C3 “Enhancements for education and science” (Table 3).

3.2.1. Sub-category C1

Fifty papers were classified as C1 and focused on the care of the patient. Examples of technologies assessed include electronic medical records, computer physician order entry, an automated test results management system, electronic systems for medication compatibility and telemedicine.

The papers split equally in terms of the classification to major and minor patient satisfaction outcome measurement. In general, the majority of the studies in this category reported a positive effect on patient satisfaction. Twenty-eight papers (56%) showed an improvement in patient satisfaction, 17 (34%) did not reveal any effect and 5 (10%) had an inconclusive effect (mixed result).

C1 was further divided into eight sub-groups (a–i). Eight papers [18–25] described different systems designed for electronic medical records (sub-category C1a). The papers showed various different effects on patient satisfaction. Only one paper out of the eight in sub-category C1a was designed as an RCT study [18]. This study evaluated the impact of a physician test result management tool with imbedded patient notification functions in a primary care setting and found an improvement in patient satisfaction.

In sub-category C1b, only one paper [26] discussed computer physician order entry and electronic prescribing systems. The paper found an improvement in patient satisfaction, which was a major outcome of the study.

A decision support application for patients with early-stage breast cancer, computerized patient-specific guidelines for management of common mental disorders in primary care

Table 3 – Summary of studies dealing with information, systems and knowledge resources.

AMIA categories of information research		Study design	Patient satisfaction major/minor	Patient satisfaction outcome
Care of the patient (AMIA category C1) [n = 50] and enhancements for education and science (AMIA category C3) [n = 1]				
C1 [n = 50]	a [n = 8]	Electronic medical records	RCT [18] Pre-Post [19–21] Cross-sectional [22] Survey [23–25]	Major [18–20,22–24] Minor [21,25] Improved [18,20,22,23,25] Mixed [24] Unchanged [19,21]
	b [n = 1]	Computer physician order entry, electronic prescribing system	Survey [26]	Major [26] Improved [26]
	c [n = 13]	Clinical decision support, reference information, decision rules, and guidelines	RCT [27–33] Pre-Post [34–38] Survey [39]	Major [27,29,32,37,39] Minor [28,30,31,33–36,38] Improved [32,33,35–39] Mixed [27] Unchanged [28–31,34]
	d [n = 5]	Workflow and process improvements systems	Non-Randomized [40] Pre-Post [41,42] Survey [43,44]	Minor [40–44] Improved [41,42] Unchanged [40,43,44]
	e [n = 3]	Nursing care systems	Non-Randomized [45] Pre-Post [46] Survey [47]	Major [45–47] Improved [45,47] Unchanged [46]
	g [n = 7]	Telemedicine and clinical communication	RCT [48] Non-Randomized [49,50] Survey [51–54]	Major [48,49,53,54] Minor [50–52] Improved [48,49,51–53] Mixed [54] Unchanged [50]
	h [n = 11]	Patient self-care, and patient–provider interaction	RCT [55–61] Survey [62–65]	Major [55,58,62–64] Minor [56,57,59–61,65] Improved [58,59,64,65] Mixed [62,63] Unchanged [55–57,60,61]
	i [n = 2]	Disease management	RCT [66] Pre-Post [67]	Major [66,67] Mixed [67] Unchanged [66]
	C3 [n = 1]	a [n = 1]	Consumer health information	RCT [68]

For more information on AMIA categories refer to Table 1. [n] = number of papers in particular category.

and computerized decision support for oral anticoagulation management were three interesting examples out of 13 papers [27–39] that addressed issues relating to clinical decision support and guidelines (sub-category C1c). The papers showed various effects on patient satisfaction. Of the seven papers designed as RCT studies, two showed a positive effect on patient satisfaction, four found no effect and one had mixed results.

There were five papers [40–44] on workflow and process improvement systems (sub-category C1d). These studies described interventions such as a clinical information system to direct and monitor physician and hospital practice, electronic system for medication reconciliation and improving clinical information flows between providers. These papers showed various effects on patient satisfaction. Three papers [45–47] reported on nursing care systems (sub-category C1e). Two papers out of the three demonstrated an improvement in patient satisfaction as a major outcome of the study.

In sub-category C1g, seven papers [48–54], discussed telemedicine and clinical communication systems. The majority of papers (five papers) showed an improvement in patient satisfaction levels. Only one paper out of the seven was designed as an RCT study. The study which evaluated a telephone-based anticoagulation service showed an improvement in patient satisfaction as a major outcome of the study.

A patient decision aid for colorectal cancer screening and computer-assisted intervention for diabetic patients were two

examples out of 11 papers [55–65] that addressed issues relating to patient self care, and patient–provider interaction (sub-category C1h). The papers presented various different effects on patient satisfaction. Out of the seven papers that were designed as RCT studies, two showed an improvement in patient satisfaction and five found no effect. The two papers [66,67] that dealt with disease management systems (sub-category C1i), also showed different effects on patient satisfaction. One had a mixed effect while the other, an RCT study, found no effect.

3.2.2. Sub-category C3

Only one paper [68] was classified as sub-category C3a, which focused specifically on consumer health information. In this RCT study the authors compared the effectiveness of a computer-based decision aid with standard genetic counseling for educating women about breast cancer genetic testing. Final analysis showed a mixed effect on patient satisfaction.

3.3. Analysis of randomized control studies

Overall, there were 20 RCTs that looked at the impact of the implementation of medical informatics on patient's satisfaction (Appendix A). The mean sample size was 331 patients (range 60–1006). The interventions were heterogeneous, but all were performed in the outpatient setting. About half (9/20) had patient satisfaction as a major outcome. While all

studies looked primarily at patients' satisfaction, only one study reported both providers' and patients' satisfaction [56]. Nine RCTs focused on providers' oriented medical informatics and 11 on patients' oriented medical informatics. Overall, 7 of the 20 (43.5%) RCTs showed statistically significant improvement in patients' satisfaction. Among the providers' oriented medical informatics and patients' oriented medical informatics, this proportion was 33.3% (3/9) and 36.4% (4/11), respectively.

4. Discussion

This systematic review demonstrated an inconsistent impact of medical informatics on patient satisfaction. While 56 original studies were found to measure patient satisfaction as an outcome for information technology intervention, it was the primary outcome in only about half of them. Moreover, only 20 studies were RCTs. Of these, 7 showed a statistically significant improvement in patient satisfaction, 11 did not reveal any significant effect and 2 had mixed results. Thus, while there is a trend towards positive impact among the trials as well as the non-randomized studies, the results vary by situation, and more evaluation including randomized studies in particular would be helpful.

Furthermore, the review clearly highlights that a vast majority of the research published (89%) dealt with medical informatics research related to care of the patient. Within this category there were 13 papers investigating clinical decision support system and 11 papers evaluating patient self care, and patient-provider interaction. These two sub-categories had also the biggest number of RCTs, seven in each. It may be argued that the reason for this might be that information technology, at present, is mainly used to focus on clinical decision support system as it offers opportunities for improved efficiency, quality of care and high economic potential [69].

In addition, we identified a notable absence of studies reporting the impact of other sub-categories of medical informatics systems on patient satisfaction, such as electronic medical records, nursing care systems and telemedicine. Our findings suggest that although the effect of information technology on patient satisfaction varies in all the sub-categories, some types have a more positive impact on patient satisfaction than others.

It is not clear however, what impact these important and growing areas of HIT have on patient satisfaction. With the growing interest and public awareness of EMRs, and taking into account the substantial focus and investment the Obama administration is placing on this and HIT in general, we are hopeful that in the next few years there may be a plethora of studies looking at the effect of these applications on patient satisfaction among other health outcomes. The growing need to prove the value of EMRs and other electronic health systems would hopefully lead to more research and better understanding of how to best improve patient satisfaction among other health outcomes through the use of information technology.

Finally, the fact that only 56 papers met our inclusion criteria with only 20 RCTs, and that only 9 of them had patient satisfaction as major outcome, suggest a need to increase the importance of patient satisfaction as indicator

and component of quality in medical informatics. Consequently, we believe that the sparse number of well designed research studies that evaluate the impact of medical informatics systems on patient satisfaction could be interpreted as a lack of researcher's awareness towards the importance of incorporating patient's perspectives into care delivery. While patient satisfaction might be considered to be a "soft" outcome as opposed to other "hard" health care outcomes, it cannot be overlooked by health care researchers and administrators. Consistent with our findings, previous literature has demonstrated that patients' perceptions and judgment of healthcare services are essential in quality of care monitoring and improvement [1–3,70–71]. We therefore, think that researchers should incorporate patient satisfaction as one of their primary outcome when evaluating medical informatics systems.

Lastly, our findings might have also policy implications. Considering the fact that patient satisfaction has become a high priority on the national agenda [3] and has received increasing public attention [3,72], health organizations in general and academic institutions in particular should consider approaches that offer researchers and administrators incentives to become more patient-oriented, and use patient satisfaction measurement tools to assess medical informatics systems.

This review has several notable limitations. The first is the quality of the study designs that were included. Systematic reviews often limit their selection of papers to RCTs, but there were so few of these that we felt compelled to retrieve all original interventional studies that addressed the research question. This allowed a broad assessment of the impact that medical informatics currently has on patient satisfaction. In addition, despite our intensive efforts we may not have identified all relevant studies as some may not be available in the PubMed database. Moreover, consistent with the manuscript's aim, we decided, to use only the MeSH term 'Medical Informatics' and exclude other related terms such as 'Health Information Technology'. Although we believe that by using the term 'Medical Informatics' the review includes the majority of the relevant studies, we are aware that we may not have identified all relevant studies. It was also beyond the scope of this review to include search terms such as consumer/customer satisfaction and patient acceptance which might have led us to miss some relevant studies. However, the primary aim of our review was to provide a focused assessment of studies that evaluated patient satisfaction with the use of medical informatics systems in healthcare. Finally, the medical informatics studies were assigned a category based on the AMIA framework. However, in some papers, more than one category could be assigned. In this situation, we assigned the paper to the category which best described the main application of the medical informatics system. We are also aware that by using the AMIA framework, a USA-based categorization of medical informatics, we may limit the generalizability of the study's results outside the USA.

In conclusion, we found that despite the increase in use of medical informatics systems and the growing importance of patient satisfaction as a quality outcome, there is an absence of well-designed research studies that evaluate the impact of medical informatics systems on patient satisfaction. While

Summary points**What was already known on the topic**

- Health information technology has established itself as a critical tool to improve health care quality and safety in the last decade.
- Patient satisfaction is increasingly recognized as an important component of quality and as an important outcome measure for clinical trials that assess the impact of health care applications.

What this study has added to our knowledge

- There is a relative paucity of highly scientific designed research that has measured the impact of health information technology on patient satisfaction.
- Despite being a promising tool to increase patient satisfaction, health information technologies did not show a clear evidence of positive impact on patient satisfaction in this literature review.
- More well designed research studies are needed in order to get a better understanding of the impact of health information technology on patient satisfaction.

there is some evidence that medical informatics improve patient satisfaction, the RCTs studies were not consistent in their findings. Although this review sheds some light on this area, clearly, more well designed research studies are needed in order to get a better understanding of this domain and accordingly find new opportunities to improve quality of care.

Author contributions

All authors contributed to the study design, which was drafted by RR, PMH and DWB. The literature review in PubMed was performed independently by RR, PMH, EG. All authors assessed and analyzed the selected articles. All authors helped draft this review, critically revised the article and approved the final version of the article.

Conflict of interest statement

The authors have no financial or commercial relationships that present a conflict of interest.

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Appendix A. Description of randomized control trials.

Author, year	Participants	Target audience	Intervention	Primary outcome	Satisfaction reported as major outcome vs. minor outcome	Satisfaction measurement tool	Results/conclusions
Provider oriented medical informatics Solomon, 1995	60	Outpatients	Use of computers in the examination room by the physicians vs. pen-and-pencil note-taking.	Patient satisfaction when physician uses a computer compared to physician taking notes.	Major	Questionnaire	No significant difference in global patient satisfaction ($P = 0.77$).

Appendix A (Continued)

Author, year	Participants	Target audience	Intervention	Primary outcome	Satisfaction reported as major outcome vs. minor outcome	Satisfaction measurement tool	Results/conclusions
Rudkin, 2006	312	Patients in emergency department	Use of digital assistant with drug database and clinical references by the physicians vs. texts.	Patient acceptance of personal digital assistant.	Minor	Questionnaire	Fifty percent reported more confidence in their emergency medicine residents and emergency medicine attendings with a personal digital assistant, while 5% reported less confidence.
Matheny, 2007	570	Primary care outpatients	Automated test result notification system to patient vs. manually tracked status orders and results by the physicians.	Patient satisfaction in overall test result communication.	Major	Telephone interview	Intervention significantly increased patient satisfaction with test results communication [OR 2.35 (95% CI, 1.05 to 5.25)].
Kinney, 2003	1006	Clients in public community based, long-term care programs	2 innovative computer-assisted, client-centered quality improvement strategies vs. usual care. Normative Treatment Planning (NTP) program, assesses needs, prescribes services, and evaluates outcomes. The second strategy, the Client Feedback System (CFS) program, provides service vendors with feedback on client perceptions of services.	Client needs and clients' satisfaction.	Major	Telephone survey	For "client needs met" NTP-only group was slightly, but significantly ($P < 0.05$), better than the control group, whereas the other intervention groups showed no significant difference from the control group. For "client satisfaction," both the NTP-only group and the CFS-only group were slightly, but significantly, better than usual care, whereas the combination group showed no significant difference.

Apkon, 2005	721	Patients in two military practices	Computerized decision support information technology tool that help caregivers close gaps between knowledge and performance vs. no exposure to this decision-support tool.	Quality of care, based on the total percentage of any of 24 health care quality process measures. Overall proportion of opportunities fulfilled in each study group within 60 days of the index visit.	Minor	Survey	No difference in the proportion of opportunities fulfilled (33.9% vs. 30.7%; $P = 0.12$). Similar response rates between the Coupler and usual-care groups (83.4% vs. 82.0%). There were no significant differences in patient satisfaction survey results in any domains of satisfaction.
Tierney, 2005	706	Primary care patients with asthma or chronic obstructive pulmonary disease	Care suggestions concerning drugs and monitoring delivered to the physicians and pharmacists when writing orders or filling prescriptions using computer workstations. Four groups of patients: physician intervention, pharmacist intervention, both interventions, and controls.	Adherence to the guidelines and clinical activity, health-related quality of life, medication adherence, and satisfaction with care.	Major	Patients' electronic medical records or telephone questionnaires	No differences between groups in adherence to the care suggestions, generic or condition-specific quality of life, satisfaction with physicians or pharmacists, medication compliance, emergency department visits, or hospitalizations.
Whelan, 2003	176	Cancer patients	Aid called the "Decision Board" to help clinicians inform patients with lymph node-negative breast cancer of the risks and benefits of adjuvant chemotherapy vs. medical consultation alone.	Patient knowledge and satisfaction.	Major	Questionnaire	Patients in the Decision Board arm were better informed about breast cancer and adjuvant chemotherapy than patients in the control arm (mean knowledge score = 80.2 [on a scale of 0–100], 95% confidence interval [CI] = 77.1 to 83.3, and 71.7, 95% CI = 69.0 to 74.4, respectively; $P < 0.001$). Satisfaction with decision making was higher for patients in the Decision Board arm than for patients in the control arm ($P = 0.032$).

Author, year	Participants	Target audience	Intervention	Primary outcome	Satisfaction reported as major outcome vs. minor outcome	Satisfaction measurement tool	Results/conclusions
Legler, 1993	80	Adult patients who presented for clinical care	Computerized medical record system during the encounter vs. standard paper-and-pencil charting.	Patient reactions to physician use of a computerized medical record system during clinical encounters.	Minor	Questionnaire	For most components of the physician–patient relationship studied, questionnaire scores did not differ significantly among the study groups. Although measured encounter durations were significantly shorter in the computer groups, there were no differences in patient satisfaction with encounter duration among the groups ($P = 0.66$).
Thomas, 2004	726	Patients with depression and anxiety	Computerized psychosocial assessment that generated a report for the GP including patient-specific treatment recommendations.	General Health Questionnaire (GHQ) score.	Minor	Postal questionnaire	The experimental group had a significantly lower GHQ score at 6 weeks, but not at 6 months. Recovery at 6 months was 3% greater among those receiving the experimental intervention (95% confidence interval [CI] = -4 to 10). Treatment group had little effect on satisfaction; for example, at 6 weeks follow-up 72% of participants receiving control treatment and 75% of participants allocated to the experimental intervention were satisfied with their GP ($P = 0.56$).

Patient oriented medical informatics

Ruland, 2003	52	Cancer patients	A computerized support system that includes (1) a comprehensive patient assessment tool for cancer-specific symptoms; functional problems; and preferences along physical, psychosocial, emotional, and spiritual dimensions; and (2) a shared decision making care planning. Assessment summaries were printed and given to the patient and clinician in the subsequent consultation vs. no summary provided.	Congruence between patients' reported symptoms and preferences and those addressed in the patient consultation.	Minor	Questionnaire	Significantly greater congruence between patients' reported symptoms and those addressed by their clinicians in the experimental group ($P < 0.01$). There were no significant group differences in patient satisfaction ($P = 0.45$).
Rostom, 2002	51	Peri-menopausal women	Interactive computerized delivery methods providing information about long-term hormone replacement therapy vs. a validated audio-booklet version of the same intervention.	Efficacy of an interactive computerized decision aid for women considering long-term hormone replacement therapy.	Major	Questionnaire	The computerized decision aid improved realistic expectations by 52.7% over baseline versus 27.6% with the audio-booklet ($P = 0.015$). Knowledge scores improved by 17.5 and 8.4% for the computer and standard DA groups, respectively ($P = 0.019$).

Author, year	Participants	Target audience	Intervention	Primary outcome	Satisfaction reported as major outcome vs. minor outcome	Satisfaction measurement tool	Results/conclusions
Fitzmaurice, 1996	49	Patients in primary care	Computerized decision support (DSS) for oral anticoagulation monitoring in primary care vs. through the local hospital laboratory.	Clinical outcomes, adverse events and patient acceptability.	Minor	Postal questionnaire	There were significant improvements in INR control from 23% to 86% ($P > 0.001$) in the practice where all patients received dosing through DSS. Twenty-five (56%) anonymous patient satisfaction questionnaires were returned with only two (8%) patients expressing any dissatisfaction with the practice clinic.
Waterman, 2001	300	Patients at health centers who are on warfarin	Multidisciplinary, telephone-based anticoagulation service (ACS) to manage patient's warfarin vs. no ACS access.	International normalized ratio (INR) monitoring, perceived safety of warfarin, overall satisfaction with their warfarin management.	Major	Face-to-face questionnaire	Patients at ACS-available health centers were more satisfied with the timeliness of getting blood test results (mean 4.31 vs. 4.03, $P = 0.02$).
Tuil, 2007	180	Patients undergoing IVF and intracytoplasmic sperm injection (ICSI) in an academic research environment	Internet-based personal health record vs. no Internet-based record.	Patient empowerment (measured as a multidimensional concept consisting of self-efficacy, actual and perceived knowledge, and involvement in the decision process), patient satisfaction, meaning of infertility problems, social support, anxiety, and depression.	Major	Questionnaire	No significant differences were observed in per person change in patient empowerment, in patient satisfaction ($P = 0.83$), the meaning of infertility problems, social support, anxiety, and depression.

Green, 2005	111	Women referred for genetic testing for inherited breast cancer risk	Counseling preceded by use of a computer-based decision aid (an interactive, multimedia, CD-ROM decision aid designed to educate women about breast cancer, heredity, and positive and negative aspects of genetic testing) vs. genetic counseling provided by certified genetic counselors.	Perceived overall effectiveness of the genetic counseling sessions (counseling alone versus counseling preceded by use of a computer-based decision aid).	Minor	Questionnaire	Participants and counselors both rated the counseling sessions as highly effective, whether or not the sessions were preceded by computer use. For the clients, the level of personal satisfaction with the session was similar between the counselor group and the computer group (3.8 vs. 3.8, $P=0.81$). For the counselors, the level of personal satisfaction with the session was similar between the counselor group and the computer group (3.1 vs. 3.2, $P=0.09$).
Ross, 2004	107	Patients with heart failure in a specialty practice	The SPPARO (System Providing Access to Records Online) software consisted of a web-based electronic medical record, an educational guide, and a messaging system enabling electronic communication between the patient and staff. Patients in the control group continued to receive standard care in the practice.	Doctor-patient communication, adherence, patient satisfaction and health status.	Minor	Survey	At 12 months, the intervention group was not found to be superior in self-efficacy (KCCQ self-efficacy score 91 vs. 85, $P=0.08$), but was superior in general adherence (MOS compliance score 85 vs. 78, $P=0.01$). Patient satisfaction with doctor-patient communication did not demonstrate a significant improvement ($P=0.13-0.80$).

Appendix A (Continued)

Author, year	Participants	Target audience	Intervention	Primary outcome	Satisfaction reported as major outcome vs. minor outcome	Satisfaction measurement tool	Results/conclusions
Dolan, 2002	96	Patients at average risk for colorectal cancer seen in an Internal Medicine practice	Decision aid designed to help patients choose among currently recommended colorectal cancer screening programs.	Patient decision process and the decision outcome.	Minor	Interview	Patients who used the decision aid had lower decisional conflict regarding colorectal cancer screening decisions (F ratio 6.47, $P=0.01$) due to increased knowledge, better clarity of values, and higher ratings of the quality of the decisions they made. There was no difference between the groups in decision outcomes.
Williams, 2007	866	Adult type 2 diabetes patients in heterogeneous primary care settings	Computer-assisted diabetes care intervention.	Perceived autonomy support, perceived competence, patient satisfaction, glycemic control (HbA1c), ratio of total to HDL cholesterol, diabetes distress, and depressive symptoms.	Minor	Questionnaire	The computer-assisted intervention increased patient perception of autonomy support relative to a computer-based control condition ($P=0.05$). Change in perceived competence partially mediated the effects of increased autonomy support on the change in lipids, diabetes distress, and depressive symptoms. The construct of autonomy support was found to be separate from that of patient satisfaction.

Morgan, 2000	240	Ambulatory patients	Ischemic Heart Disease Shared Decision-Making Program (IHD SDP) an interactive videodisc designed to assist patients in the decision-making process involving treatment choices for ischemic heart disease. Control group did not receive any additional educational material from the study investigators.	Patient satisfaction with the decision-making process.	Major	Questionnaire	Shared decision-making program scores were similar for the intervention and control group (71% and 70%, respectively; 95% confidence interval for 1% difference, -3% to 7%).
Green, 2004	211	Women with personal or family histories of breast cancer	Computer-based decision aid with standard genetic counseling for educating women about BRCA1 and BRCA2 genetic testing vs. standard one-on-one genetic counseling.	Participants' knowledge, risk perception, intention to undergo genetic testing, decisional conflict, satisfaction with decision, anxiety, and satisfaction with the intervention.	Minor	Questionnaire	Knowledge scores increased in both groups ($P < 0.001$) regardless of risk status, and change in knowledge was greater in the computer group compared with the counselor group ($P = 0.03$) among women at low risk of carrying a mutation. The counselor group had lower mean scores on a decisional conflict scale ($P = 0.04$) and, in low-risk women, higher mean scores on a satisfaction-with-decision scale ($P = 0.001$) compared with the computer group.

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