Final Report
PART I

Computer-Based Delivery of Health Evidence: A Systematic Review of Randomised Controlled Trials and Systematic Reviews of the Effectiveness on the Process of Care and Patient Outcomes

Final Report to
The Alberta Heritage Foundation
for Medical Research

January 2003

Final Report to the
Alberta Heritage Foundation for Medical Research

Computer-Based Delivery of Health Evidence: A Systematic Review of Randomised Controlled Trials and Systematic Reviews of the Effectiveness on the Process of Care and Patient Outcomes

January 2003

Partners:
The Alberta Research Centre for Child Health Evidence, Department of Paediatrics, University of Alberta
Centre for Community Child Health Research, University of British Columbia

Authors:
Kristie Cramer, Lisa Hartling, Natasha Wiebe, Kelly Russell, Ellen Crumley, Dr. Martin Pusic, Dr. Terry P. Klassen.

For further information please contact:

Kristie Cramer
Project Coordinator
Alberta Research Centre for Child Health Evidence
9428 Aberhart Centre One
11402 University Avenue
Edmonton, Alberta
T6G 2J3
Phone: 780.492.6184
Fax: 780.407.6435
Email: **kcramer@ualberta.ca**

Executive Summary

Over the past decade, health care professionals have been encouraged to "integrate the best research evidence (i.e., clinically relevant research) with clinical expertise and patient values" when making clinical decisions[1]. That is, they have been encouraged to practice Evidence-Based Medicine. To maintain up-to-date and innovative clinical decision-making, health care professionals need to regularly search for, review, and appraise current evidence. This can be challenging, as providers often do not have the skills and/or time to successfully retrieve and appraise health evidence.

In an effort to assist health care providers with successfully searching for, translating, and integrating the best clinical evidence at the point-of-care, computer-based evidence delivery systems have been developed. These systems have been designed to assist providers with diagnosis, prescription, managing diseases, and preventing diseases. In addition to assisting health care providers, these systems have been designed to assist health care consumers by guiding them in their health behaviours, treatment options, and disease management.

As with any innovative health care intervention, computer-based evidence delivery systems need to be rigorously evaluated before their use becomes widespread[2]. One method for providing an evaluation is to summarize the existing evidence in a systematic review. Systematic reviews use explicit and reproducible methods for identifying and selecting studies and assess the methodological quality of each study with respect to the strength of evidence it contains. This approach ensures that any conclusions drawn from the available literature are based on the highest quality evidence available and that gaps in the literature base are identified.

We report a systematic review of published and unpublished randomised controlled trials and systematic reviews that assess the effectiveness of computer-based evidence delivery systems. In this review, a comprehensive search of the literature identified 13,570 documents of which 525 were deemed potentially relevant. Two reviewers independently screened these articles for relevance using a predetermined set of inclusion criteria and identified 57 relevant randomised controlled trials and 10 relevant systematic reviews. The majority of these studies were rated as having low methodological quality and were therefore open to substantial bias. The majority of the randomised controlled trials were published between 1995-2001 (n=33) and were conducted in North America (n=46). Nine of the systematic reviews were published between 1995-2001 and six were published in North America.

Eighteen of the 57 randomised controlled trials investigated systems designed specifically for patient users, 37 studies investigated systems designed specifically for health care providers, and two studies investigated systems designed for use by both patients and health care providers. Five studies investigated diagnosis systems, 30 investigated management systems, one investigated a prediction system, four investigated prescription systems, nine investigated prevention systems, six investigated support systems, and two investigated treatment systems. The primary outcomes measured varied considerably from study to study and were categorized into one of three groups: process of care (e.g., compliance with medical guidelines), patient health (e.g., blood pressure), and other (e.g., knowledge).

When the data from these studies were pooled, use of these systems was found to enhance the process of care. However, some studies showed a positive effect of these systems on the process of care whereas other studies did not. The variability among the findings of these studies is likely a result of the various differences between the studies such as the intervention studied, the methodological quality, or the specific outcomes assessed. Overall, the use of computer-based evidence delivery systems was not found to have an impact on patient health outcomes. However, there were very few studies that investigated patient health outcomes and in most cases, the studies were too small to detect an effect. In addition, to have an effect on patient health outcomes, these systems must first have an effect on the process of care. Thus it may be too early to investigate patient health outcomes[2]. The effect of these systems on the process of care needs to be enhanced prior to investigating their effect on patient health outcomes.

Six of the ten systematic reviews included studies with experimental designs other than randomised controlled trials and three of the ten assessed studies with designs other than controlled clinical trials. Two included investigations of non-computerized as well as computerized information systems. Eight reviews investigated the effects of these systems on the process of care and seven found a benefit. The effect of these systems on patient health outcomes was tested in eight systematic reviews and four documented a benefit. These findings are consistent with the findings of our review of randomised controlled trials.

Several implications and recommendations for future areas of research can be suggested from this review. First, there is considerable potential for improving the dissemination and use of medical evidence. Future studies employing a qualitative approach are required to identify the barriers to using medical evidence and, where these barrier are inappropriate, the methods to remove them. In addition, because the results of the included studies varied (i.e., some found a benefit of using a computer-based evidence delivery system others did not) further research needs to focus on identifying the specific aspects of a system that contribute to its success or failure. This information will prove key to developing and implementing computer-based evidence delivery systems in the future.

Acknowledgements

The Alberta Heritage Foundation for Medical Research provided the funding for this project. In addition, the following individuals assisted us by providing their expertise and knowledge of medical informatics:

Deborah Wilson:	Program Director, Clinical Practice Guidelines Department, Alberta Medical Association
Elaine Stakiw:	Director of Research and Evidence, Alberta Health and Wellness
Paul Childs:	Health Economist, Alberta Health and Wellness
Don Philippon:	Executive Director and Vice Chair, Health Sciences Council, University of Alberta
Elaine Orrbine:	Chief Executive Officer, Canadian Association of Pediatric Health Centers
Sharon Richardson:	President, Alberta Association of Registered Nurses
Robert Hayward:	Director, Centres for Health Evidence
Micheal Bullard:	Physician, Division of Emergency Medicine, University of Alberta Hospital
Donna Strating:	Vice President Informatics, Capital Health
June McGreggor:	Chief Operating Officer, WELLNET

Table of Contents

Chapter 1: Introduction

Over the past decade, health care professionals have been encouraged to "integrate the best research evidence (i.e., clinically relevant research) with clinical expertise and patient values" when making clinical decisions[1]. That is, they have been encouraged to practice Evidence-Based Medicine. To maintain up-to-date and innovative clinical decision-making, health care professionals need to regularly search for, review, and appraise current evidence. This is challenging given that many providers do not have the skills required to successfully retrieve and appraise health evidence. If they have the skills, they often do not have the time. To add to the challenges of practicing evidence-based medicine, providers are confronted with a wealth of health evidence that is growing at a rapid pace. Remembering enough of this information to integrate into decision-making is not humanly possible[3].

In an attempt to ease this information overload and decrease the amount of time and effort required for keeping up-to-date, computer-based health evidence delivery systems have been developed. These systems are designed to assist health care providers with searching for, translating, and integrating the best clinical evidence at the point-of-care. Computer-based evidence delivery systems cannot replace health care providers since even the most sophisticated systems require professional judgement to accurately identify situations where the information does not apply and to assure the accuracy of the data[4]. The function and format of these systems varies considerably. Databases, interactive websites, and decision support software systems provide ready access to current research, practice guidelines, and decision-making tools. These systems can be active or passive. Active systems generate information based on patient data without a specific request; passive systems provide information at the user's request[5]. Systems have been developed to assist providers in diagnosis, managing disease, and preventing disease. For example, ProtoVIEW provides protocol information for diagnostic and therapeutic purposes[6]; the Asthma Crystal Byte provides patient specific asthma decision support based on current asthma guidelines[7]; and, CAMP (Computer Assisted Management Protocol) provides guideline-based patient specific management recommendations for patients with diabetes[8].

In addition to assisting providers, several computer-based health evidence delivery systems have been designed to assist health care consumers. Today's health care consumers are becoming more knowledgeable with respect to their medical conditions and treatments and are playing a greater role in their health care decisions and management[9]. Numerous programs have been developed to guide patients in their health behaviours, treatment options, and disease management. For example, CHESS (Comprehensive Health Enhancement Support System) provides patient education on breast cancer through a personal computer[10]; Homer et al. developed an interactive educational computer program designed to teach children about asthma and its management[11]; and, O'Conner et al. tested a self-administered computer aid for post-menopausal women considering long-term preventive hormone therapy[12].

Bringing relevant information to providers at the point-of-care has the potential to affect practice patterns, enhance or alter decisions being made, increase efficiency in practice, and ultimately improve health outcomes for patients. By taking a more active role in the clinician-patient relationship, patients may acquire a greater sense of control - a key determinant of health[13].

As with any innovative health care intervention, these systems need to be rigorously evaluated before their use becomes widespread[2]. A large number of randomised controlled trials and systematic reviews have examined their effectiveness[2 7 10 14-77]. However, it is difficult to draw general conclusions from this body of literature because the methodological quality of these studies varies and the findings are inconsistent. In addition, previous reviews have not assessed the methodological quality of the studies, they only provide a qualitative assessment of these systems, and they do not address publication bias (studies with negative results remaining unpublished). A comprehensive and systematic evaluation of these systems is therefore required.

One method for providing an evaluation of these systems is to summarize the existing evidence. A summary provides policy makers and program planners with an overview of the available evidence and it can identify gaps in the research. A popular and widely accepted approach to summarizing the existing evidence within the health care and social sciences field is the systematic review[78]. Systematic reviews use explicit and reproducible methods for identifying and selecting studies and assess the methodological quality of each study with respect to the strength of evidence it contains. This approach ensures that any conclusions drawn from the available literature are based on the highest quality data available and that gaps in the literature base will be identified.

We report a systematic review of published and unpublished randomised controlled trials and systematic reviews assessing the effectiveness of computer-based systems that deliver health evidence (or evidence based recommendations). In this review we assess the methodological quality of these studies, provide a qualitative and quantitative analysis of these systems, and address the possibility of missing studies due to publication bias. We have expressly limited the scope of this review to randomised controlled trials and systematic reviews as they represent the highest quality of evidence regarding the effectiveness of an intervention. We have excluded studies of systems that produce printed outputs/reminders to be mailed to patients; systems that telephone patients; systems that calculate/administer drug dosages; or systems that store medical records. These systems are transaction processing or administrative systems not evidence delivery systems since they only perform administrative tasks and do not transform, integrate, or deliver evidence[4].

Chapter 2: Goals and Objectives

2.1 Goals

The purpose of this review was to systematically identify and synthesize randomised controlled trials and systematic reviews that evaluate the effectiveness of computer-based health evidence delivery systems on the process of care and/or patient health outcomes.

2.2 Objectives

The specific objectives of this project were to:

A. Systematically and comprehensively search and identify relevant randomised controlled trials and systematic reviews that assess the effectiveness of any computer system that delivers health evidence to patients and/or health care professionals.

B. Assess the methodological quality of the existing evidence.

C. Describe included studies in terms of methods, study population, intervention, results, and conclusions.

D. Evaluate the effectiveness of these systems using quantitative or qualitative methods as appropriate.

Chapter 3: Methods

3.1 Search Strategy

A medical librarian developed specialized search strategies for each electronic resource listed below. The search strategies are outlined in Appendix A and were used to search for randomised controlled trials and systematic reviews. In light of the volume of literature in this area, the electronic databases were searched from 1990 to the present. References from a similar systematic review were used as a basis for identifying relevant studies prior to 1990[70].

The following databases were searched: Medline (1990-2002), EMBASE (1990-2002), CINAHL (1990-2002), Cochrane Controlled Trials Register (1990-2002), Web of Science (1990-2002), and the trial registry of the Cochrane Effective Practice and Organization of Care Group (1990-2002). In addition, two reviewers independently hand-searched the Health Information and Libraries Journal (1990-2002), Journal of the Medical Library Association (1990-2002), Medical Reference Services Quarterly (1990-2002), and the Proceedings of the American Medical Informatics Association (1991-2002). Reference lists from all relevant articles were reviewed and potentially relevant studies were retrieved. In addition, individuals from companies (Appendix B) that produce relevant products were contacted for information about relevant studies. Finally, authors of all relevant articles and experts in the field are being contacted for information on recent, ongoing, or unpublished studies.

3.2 Screening

Two reviewers independently reviewed the titles and abstracts (where available) of all the studies generated from the electronic searches. All references referring to the use of computer-based delivery of health evidence were flagged as potentially relevant. The full manuscripts of these studies were then retrieved. Two reviewers independently hand-searched the journals listed above. Each reviewer identified and photocopied articles thought to be relevant. Finally, a reviewer scanned the reference lists of all the relevant studies and the full copy of any study that appeared to be related to computer-based delivery of health evidence was retrieved.

3.3 Inclusion/Exclusion

Two reviewers independently assessed the full articles of each potentially relevant study by applying a pre-determined set of eligibility criteria. At each stage, discrepancies between the two reviewers were resolved through discussion and, when necessary, consultation with a third reviewer. The eligibility criteria for randomised controlled trials and systematic reviews are as follows (see appendices C and D):

<u>3.3.1 Randomised Controlled Trials (RCT)</u>

1) *Types of studies*: randomised controlled trials, quasi-randomised controlled trials. 2) *Types of participants*: health care professionals or patients. 3) *Types of interventions*: computer-based delivery of health evidence (e.g., world wide web, bibliographic databases, clinical decision support systems, computer-based patient materials). As explained above, studies on the following types of interventions were not included: dosage calculators, administration, and assistance systems. 4) *Types of outcome measures*: process of care (e.g., provider/patient compliance with the computer system's

recommendations, treatment behaviour explained by adherence to guidelines or best evidence) and patient health outcomes including any aspect of patient well-being (i.e., patient satisfaction, mortality, decision skill/confidence, blood pressure).

3.3.2 Systematic Reviews

The following specific inclusion criteria were applied to the systematic reviews: 1) *Types of studies:* systematic reviews. 2) *Types of study selection methods:* specific inclusion/exclusion criteria reported. 3) *Types of* i*nterventions reviewed:* computer-based delivery of health evidence. 4) *Types of participants reviewed:* patients and/or health care providers as the types of participants listed in their inclusion/exclusion criteria.

3.4 Methodological Quality

Two reviewers independently assessed the methodological quality of each relevant study using the Jadad score[79] and allocation concealment[80] for randomised controlled trials and Oxman and Guyatt's index of scientific quality for the systematic reviews[81]. In addition, for the randomised controlled trials the reviewers identified whether there was a unit of analysis error and whether the study was contaminated (defined below). Discrepancies between the two reviewers were resolved by discussion.

3.4.1 Randomised Controlled Trials

Methodological quality of these trials was assessed using validated quality assessment tools, the Jadad scale[79] (see Appendix E) and the component of allocation concealment as described by Schulz[80]. The Jadad scale scores methodological quality, on a scale from 0 (lowest quality) to 5 (highest quality), based on randomisation, double-blinding, and reporting of withdrawals and drop-outs[79]. Allocation concealment was assessed as adequate, inadequate, or unclear[80].

If the unit of randomisation differed from the unit of analysis the study was considered to have a unit of analysis error (e.g., the unit of randomisation was clinics but the unit of analysis was patients). This type of error can result in overly precise confidence intervals, in other words, statistical significance when there should not be. If the knowledge gained by the intervention group could be applied to the control group, the study was considered contaminated. For example, a study is contaminated when the same health care provider treats patients in the intervention group and patients in the control group. This can result in an underestimate of the intervention's effect.

3.4.2 Systematic Reviews

The methodological quality of the systematic reviews was assessed using Oxman and Guyatt's index of the scientific quality of research overviews[81] (see Appendix F). This tool scores quality on a scale from 1 (lowest quality) to 7 (highest quality), based on the extent to which bias is avoided in searching for studies, selecting studies for inclusion, assessing study quality, pooling results, and reaching overall conclusions.

3.5 Data Extraction

Information from included studies was extracted using a standard data extraction form. Different data extraction forms were used for randomised controlled trials (see appendix G) and systematic reviews (see Appendix H). One reviewer extracted the data and a second reviewer checked the data for accuracy and completeness and entered it into spreadsheet software. Any discrepancies between the two reviewers were discussed and resolved by referring to the original study.

3.5.1 Randomised Controlled Trials

The following information was extracted from each randomised controlled trial: year and country of publication; funding source; study objectives; study design; study setting; participants; number of participants; goal of intervention; user of intervention; active or passive intervention; whether an intention-to-treat analysis was planned; results; primary outcome type; how the primary outcome was selected (i.e., stated versus inferred); the selected results; and, authors' conclusions.

For each study, the setting was defined as inpatient, outpatient, home, or other (e.g., conference); the goal of the intervention was categorized as diagnosis (e.g., assists with making a diagnosis), management (e.g., provides information on the best ways to manage a chronic illness), prediction (e.g., predicts abnormal test results), prescription (e.g., provides guidelines on prescribing methods), prevention (e.g., provides information on prevention strategies), support (e.g., allows one to ask questions, interact with others with the same disease, and educational information), and treatment (e.g., provides information on the best way to treat an acute injury/illness); and user of the intervention was defined as patient or provider (i.e., nurses, clinicians, residents, family caregivers etc.). Active systems provide information based on entered data without a specific request; passive systems provide information at the user's request.

If it was not clear which outcome was the primary outcome, the outcome that was most relevant to the author's objectives was extracted. If there was more than one outcome relevant to the author's objectives the first one reported in the results section was extracted. The method used to identify the primary outcome was recorded (i.e., ‘stated’ in the study versus ‘inferred’ based on the criteria listed above). Outcomes were classified into one of three categories: process of care (e.g., provider/patient compliance with the computer system’s recommendations/best evidence, health care behaviour explained by adherence to guidelines or best evidence), patient health (e.g., blood pressure, potassium levels, weight) and other (e.g., knowledge). If the study included more than one of the three types of outcomes, two were extracted: the primary outcome and one of the secondary outcomes. All of the primary and secondary outcomes with complete data were included in the meta-analysis.

3.5.2 Systematic Reviews

The following information was extracted from each systematic review: year and country of publication; objective of review; inclusion/exclusion criteria used; total number of included studies; key results; and author’s conclusions.

3.6 Data Analysis

3.6.1 Randomised Controlled Trials

Data were analysed using Stata 7.0[82]. The data were primarily analysed as standardized mean differences (SMD's). That is, differences in units of (pooled) standard deviations. Dichotomous data were calculated as odds ratios (OR's) and then converted to standardized mean differences[83]and combined with the continuous data. The subsets of dichotomous data were also analysed separately as odds ratios to increase the comprehensibility of the SMD’s, which are difficult to interpret. Overall SMD’s and OR’s were calculated along with their 95% confidence intervals.

Heterogeneity was calculated using the Chi-square test[84]; values that did not exceed P=0.10 were considered significant. Possible sources of heterogeneity were assessed by subgroup analyses on all three outcomes (i.e., process of care, patient health outcome, knowledge) using meta-regression. The moment-based estimate for tau-squared and the natural logarithm of total sample size were used to account for between-study heterogeneity and to adjust for publication bias, respectively. The following clinical and methodological subgroups were explored and are presented in Table 1: Clinical - goal of intervention, type of intervention (active or passive), user of the intervention, study setting, and country; Methodological - funding source, Jadad Score, allocation concealment, intention-to-treat, contamination, non-independence, and study design. In addition, sensitivity was assessed for the following factors (Table 1): primary versus secondary outcome, selection of primary outcome (i.e., stated or inferred), converted binary data, loss to follow-up, and design effect for cluster studies. Sensitivity was assessed in the following ways: where cluster design trials did not consider intra-cluster correlation (ICC), a design effect was used to effectively increase standard error; a small ICC of 0.2 was used since the four studies [14 46 60 66]that did report on the ICC found the unadjusted analysis unaffected. ITT analyses were performed on dichotomous data only where there was reported loss to follow-up. Highly influential points were identified and explored for impact on the overall estimate.

Heterogeneity, whether quantitatively measured or not, always exists in a meta-analysis. No two studies are exactly alike. In this systematic review, clinical and statistical heterogeneity were expected to be large given that most studies investigated different computer-based evidence delivery systems. Since the statistical (effect sizes are roughly within 2 standard deviation units of each other) and clinical heterogeneity were not too large to make the inferences inconsequential, the reviewers decided to combine the data. When heterogeneity exists, Bailey (1987) suggests the reviewers consider the primary question they are asking. This affects the model used to combine the results. The fixed effects model was chosen ‘a priori’ to answer the question of whether these systems "could" change process of care or improve patient health outcomes. In other words, can some systems be effective in some circumstances? The random effects (RE) model answers the question of "would" these systems change process of care or improve patient health outcomes for any given patient. RE models were considered in sensitivity analyses. The advantage of combining is that it gives an overall quantitative or “top view” look at the “average” system. The average system defined as all the common components between the systems. Given that combining is only able to provide an overall “top view” of the “average” system, a qualitative description of the systems studied is also provided. This qualitative review provides a closer look at the various systems in terms of their goal, user, type (i.e., active versus passive), clinical area, and primary outcome. An additional advantage to combining is that it allows us to consider publication bias.

Publication bias is an estimate of the association between the publication success of studies and their magnitude and direction of effect. Studies that provide negative results are more likely to remain unpublished than studies that provide evidence supporting the intervention being assessed[85]. Publication bias was assessed visually using a funnel plot and quantitatively using the adjusted rank correlation test [86], the weighted-regression asymmetry test[87], and the trim and fill method[88]. Funnel plots, which depict publication bias, graph some measure of study precision (e.g., one divided by the standard error) against some measure of effect (e.g., standardized mean difference). In the absence of publication bias, the funnel plot should resemble an inverted funnel. Smaller studies naturally (or statistically) give a wide range of effect sizes. They are less stable because they contain less information. Thus, at the base of the inverted funnel one would expect to see the widest spread. At the top of the funnel, the SMD's converge at a point when there exists a trial that is sufficiently large to be relatively stable.

3.6.2 Systematic Reviews

The overall findings and conclusions of each systematic review are summarized and discussed.

Chapter 4: Results

The combined search efforts identified 13,570 documents. The initial screen identified 525 articles as potentially relevant to the review (Figure 1). Of these 525 potentially relevant studies, 57 randomised controlled trials[14 7 10 15-68]and ten systematic reviews[2 69-77] were included in the review. Thirty-six studies are still waiting assessment as twenty-nine have not been received from the University of Alberta's interlibrary loan service and seven are not English and require translation. These 36 studies will be assessed for inclusion and added to the analysis if relevant. The most common reasons for excluding studies were that they were not randomised controlled trials or systematic reviews and/or they did not investigate a relevant intervention. Other reasons for excluding studies include: the intervention did not deliver evidence (e.g., computerized questionnaires, computer assisted surgery, computerized intervention/therapy); it was not computerized; it was purely administrative (e.g., computerized record keeping). The reasons for excluding questionable studies are listed in Table 2.

4.1 Randomised Controlled trials

4.1.1 Description of Included Studies

Table 3 describes the 57 randomised controlled trials in terms of year and country of publication, setting, sample size, and methodological quality. As a result of the nature of the intervention most of these studies could not double-blind resulting in a maximum Jadad score of 3 rather than the conventional 5. Accordingly, a bias in favour of the intervention was introduced and the overall quality of these studies was low with a median quality score of 2 (range 0-3). Allocation concealment was unclear in 51 of the 57 randomised controlled trials contributing to the bias in favour of the intervention. Nineteen of the 57 studies ignored possible intra-cluster correlation thereby introducing a unit of analysis error that also contributes to an underestimate of the effect's variation. In addition, 35 of the 57 studies were contaminated such that knowledge gained by the intervention group could be applied to the control group. This may lead to an underestimate of the intervention's effect.

The majority of the included studies were published between 1995-2001 (n=33) and were conducted in North America (n=46). Thirty-five of the studies were conducted in an outpatient setting[7 14-19 21-24 26 27 30 32 34 36 38 39 41 43-50 53 54 60 63 65], ten in an inpatient setting[20 25 35 37 51 55 56 64 66 68], ten in the patient's home[10 28 29 31 40 42 52 57 58 67], and two were carried out at conferences[33 61]. The primary outcomes measured varied considerably among the studies and were categorized into one of three groups: process of care (e.g., change in diet, compliance with medical guidelines, changes in prescribing patterns); patient health outcomes (e.g., blood pressure, cholesterol levels, weight); and, other (e.g., knowledge acquisition, decision-making confidence). The primary outcome was categorized as a process of care outcome in thirty studies, a patient health outcome in nine studies, and an "other" outcome in 18 studies. Diagnostic systems were investigated in five studies[89-93]; management systems in 30 studies[94-101]; prediction systems in one[16]; prescription systems in four[32 37 49 51]; prevention systems in nine[14 33 35 43 45 54 57 62 64]; support systems in six [10 28 31 40 58 59]; and, treatment systems in two[27 53].

Eighteen studies investigated systems designed specifically for patient users[10 19 22 26 27 36 38-40 42 50 52 55-58 62 67]. Three of these studies investigated the same system (CHESS) designed for use with different diseases (i.e., breast cancer, AIDS)[10 40 58]. Thirty-seven studies investigated systems designed specifically for health care providers[7 14-18 20 21 23-25 28-35 37 41 43 44 46-49 51 53 59-61 63-66 68]. Three of these studies were investigations of the ComputerLink system[28 29 31] and two were investigations of the Regenstrief Medical Record System (RMRS)[64 66]. Finally, two studies investigated systems designed for use by both patients and health care providers[45 54].

4.1.2 Outcomes – Meta-Analysis

Process of care: Thirty-six studies reported a process of care outcome, seven of these studies were not included in the analysis because they did not provide sufficient data. Therefore, a total of 29 studies were included in the analysis using overall SMD's. Seventeen of these studies presented dichotomous data and were also analysed separately using overall OR's.

Patients/providers adhered to the recommendations/best evidence 57% of the time with the use of computer-based health evidence delivery systems and 52% of the time without. Users complied with the best evidence significantly more often when using a computer-based health evidence delivery system (FE SMD 0.14, 95%CI [0.13,0.16] n=29; FE OR 1.28, 95%CI [1.24,1.32] n=17; Figure 2).

Publication bias (Figure 3) methods for process of care outcomes provide evidence to suggest that studies favouring control interventions are missing (the rank correlation test, P=0.028; weighted regression, P<0.001; and the trim and fill method, 13 missing studies). The unadjusted RE SMD is more biased than the unadjusted FE SMD because small studies are assigned disproportionately greater weights as compared to larger studies by the RE method thereby giving more benefit to the intervention. To account for this bias, the RE SMD was adjusted by the trim and fill method. This estimate (0.16, 95%CI [0.03,0.30]) was significant and centred similarly to the FE SMD.

Between-study heterogeneity was significant at P<0.001. Two of the 17 subgroups were statistically significant. Provider users (clinicians, residents, nurse practitioners) experienced more benefit (coefficient –0.42 P=0.014 n=18) than patient users (n=8) according to the meta-regression, however, an alternative subgroup test by Deeks (2001) show the opposite effect. North American studies (coefficient 0.53 P=0.002 n=23) exhibited more benefit than studies conducted in Australia and Europe (n=5). However, these results are exploratory as there are multiple comparisons. Neither the ITT analysis nor the cluster studies with increased standard errors appreciably affected the overall estimates.

Patient Health Outcomes: Seventeen studies reported a patient health outcome, five of these studies were not included in the analysis because they did not provide sufficient data. Therefore, a total of 12 studies were included in the analysis using overall SMD's. Three of these studies presented dichotomous data and were also analysed separately using overall OR's.

In the majority of the studies, the desired outcome was represented by a lower numerical value. In cases where a high value represented the desired outcome, the value was converted so that a low value represented the desired outcome. The intervention and control groups did not significantly differ (FE SMD –0.02, 95%CI [-0.08,0.04] n=12; FE OR 0.86, 95%CI [0.66,1.12] n=3; Figure 4) with respect to patient health outcomes.

Publication bias (Figure 5) results for patient health outcomes were incongruent. The rank correlation test did not indicate the presence of a publication bias at the 0.05

level (P=0.064) but did at the 0.10 level. The trim and fill method did not indicate any missing trials, providing evidence to suggest that publication bias was not present for the patient health outcomes. Conversely, the weighted regression provided evidence for publication bias (P=0.037) favouring the intervention.

Between-study heterogeneity was significant at P=0.068. One of the 17 subgroups, funding, was statistically significant. Studies that were privately funded were significantly more likely to find a benefit in patient health outcomes (coefficient –0.34 P=0.026 n=1) with use of computer-based evidence delivery systems than studies that were funded by the government (n=5). The sensitivity analysis indicates that the overall FE SMD was not significantly affected by adjusting the cluster design results for the assumed ICC.

Knowledge Outcome: Since several (10) of the studies investigated the effect of these systems on the acquisition of patient and/or provider knowledge, it was decided (post-hoc) to examine this variable. For the combined continuous and dichotomous outcomes, knowledge acquisition was significantly better with the use of computer-based delivery of health evidence (FE SMD 0.50, 95%CI [0.34,0.65] n=10; Figure 6). However, when the subset of dichotomous outcomes were analysed knowledge acquisition did not differ significantly between the two groups (FE OR 0.92, 95%CI [0.47,1.79] n=2).

All tests for publication bias were negative except the trim and fill method that indicated two studies favouring the control intervention were missing. Visually, the funnel plot appears asymmetrical (Figure 7). The adjusted trim and fill RE SMD was 0.44 (95%CI [0.13,0.75]). The rank correlation test was P=0.107 and weighted regression was P=0.135 for bias.

Between-study heterogeneity was significant at P<0.001. The exploratory subgroup and sensitivity analyses were not statistically significant.

4.1.3 Description of Studies by Goal of Intervention

The studies were grouped into one of seven categories based on the goal of the intervention investigated: diagnosis, management, prediction, prescription, prevention, support, and treatment. These categories were then used to describe the studies in terms of user of the intervention, type of intervention (i.e., active versus passive), clinical area, and the primary outcome extracted. Descriptions of each study, by goal of the intervention, are presented in Tables 4-10. In addition, detailed definitions of each system are provided in Appendix I.

Diagnosis

Five studies evaluated four unique systems designed to assist health care providers with diagnosis in an outpatient setting[89-93]. The four systems tested varied with respect to the clinical area for which they were designed. One was designed to assist with the diagnosis of the cause of abdominal pain[63], one for diagnosing mood disorders[30], one for diagnosing as well as managing diabetes, hypertension, and hypercholestrolemia[41 59], and one for diagnosing and managing depression[61]. These systems were rule-based decision support systems that assisted the provider by integrating patient specific information with current medical guidelines to provide patient specific diagnoses and, in some cases, management recommendations. One study measured process of care as the primary outcome and found a benefit. The system tested in this study was designed to assist providers with diagnosing mood disorders and was the only active (i.e., provides information without a specific request from the user) diagnostic system evaluated. Two studies investigated the system designed to assist with diagnosing and managing diabetes, hypertension, and hypercholestrolemia. Both of these studies measured a patient health outcome as the primary outcome, neither study found a benefit. The two remaining studies measured diagnostic accuracy (i.e., other outcome) as the primary outcome. One of these studies found diagnostic accuracy was better with the assistance of a computer based evidence delivery system.

Management

Thirty studies investigated systems intended to assist providers or patients with managing a specific disease (e.g., asthma, diabetes). The majority of the systems studied were disease specific focusing on diabetes, hypertension, asthma, eating disorders, arthritis, alcohol abuse, hyperlipidaemia, or incontinence. For example, one study investigated Diabeto, a home-based computerized education system that provides individualized counselling and disease management information to patients with diabetes[52]. Similarly, Shegog et al. investigated Watch, Discover, Think, and Act (WDTA), a computer-based program designed to teach asthma management skills to children[50]. Twelve of the systems studied were active and 18 were passive. All of the active systems were designed for health care providers whereas six of the passive systems were designed for health care providers and the other 12 were designed for patients. Fourteen studies investigated the process of care as the primary outcome; nine found a benefit. Four of the eight studies that measured a patient health outcome as the primary outcome found a benefit. Additionally, five of the seven studies that assessed knowledge as the primary outcome found a benefit. All of the studies that investigated knowledge as the primary outcome investigated passive systems designed to educate patients on the management of a specific disease (e.g., diabetes, asthma). Finally, one study investigated perception of health status as the primary outcome and found a benefit.

Prediction

One study assessed the role of a computer based evidence delivery system in predicting the outcomes of abnormal test results in general practice[16]. The system studied presented providers with the probability that a medical test would show an abnormality for a specific patient when the physician ordered the test. The authors concluded that the use of such a system resulted in physicians ordering fewer low-probability tests for intervention patients than for controls. However, we were unable to extract enough information from this study to validate this conclusion.

Prescription

Four studies investigated systems designed to assist providers with prescribing drugs[32 37 49 51]. These systems were designed for health care providers in a variety of clinical areas including: otitis media, infectious diseases, hypertension, and infection. Two of the systems studied were active systems where information or reminders were provided to the user without their request. One system was passive as it provided prescribing information to the provider at his/her request and the other system was both active and passive as it provided unsolicited information to the provider based on the antibiotic he/she prescribed and then provided further information upon the user's request. The two studies of the active systems as well as the study of the active/passive system assessed process of care as the primary outcome. All three studies found a benefit. The study of the passive system assessed cost per patient (i.e., other) as the primary outcome and concluded there was a benefit.

Prevention

Nine studies investigated the role of computer based evidence delivery systems in preventative care[14 33 35 43 45 54 57 62 64]. These systems were designed for providers or patients in a variety of preventative care areas including diet, cancer, general preventative care, inpatient care, and tuberculosis. Five of the studies evaluated active provider systems that generated patient specific reminders to obtain or perform specific preventative care manoeuvres such as breast cancer screening. The other four studies assessed passive systems that provided preventative care recommendations at the user's request. All nine studies measured process of care as the primary outcome; seven found a benefit.

Support

Six studies investigated two unique computer evidence delivery systems intended to provide support for patients or their caregivers[10 28 29 31 40 58]. These two systems were designed to provide continual support in the home of patients with chronic illnesses or caregivers of patients with a chronic illness. For example, the Comprehensive Health Enhancement System (CHESS) is a home-based computer system that provides education, support, and management information to patients with breast cancer or AIDS. Similarly, the ComputerLink system is a home-based system that provides education, support, and management information to caregivers of individuals who have Alzheimer's disease. These systems provide the user with access to online medical encyclopaedias, discussion groups, and decision services. Three of the studies assessed the user's quality of life as the primary outcome; two of these studies found use of the CHESS system enhanced the patient's quality of life. Two of the studies assessed decision-making confidence as the primary outcome and both found that use of the ComputerLink system enhanced the caregiver's decision-making confidence. The final study assessed caregiver strain as the primary outcome and did not find a benefit of using the ComputerLink system.

Treatment

Two studies evaluated passive systems designed to assist with treatment decisions in outpatient settings[27 53]. One study investigated a system that presented health care providers with patient specific trauma protocols for the treatment of fractures. The other study investigated a system that provided patients with information on their treatment options for benign hyperplasia. Both of these studies evaluated the effect of these systems on the process of care (if the user complied with the information provided) as the primary outcome; neither study found a benefit.

4.2 Systematic Reviews

4.2.1 Description of Included Studies:

Thirteen systematic reviews satisfied the selection criteria. However, one review published in 1998 was an update of three previous reviews thereby resulting in the inclusion of ten reviews[2 69-77] (Table 11). Six of these reviews included studies with experimental designs other than randomised controlled trials[2 69 72 75-77] and three of the ten assessed studies with experimental designs other than controlled clinical trials[72 76 77]. In addition, two reviews included an investigation of non-computerized as well as computerized information systems[69 72]. The overall quality of these reviews was found to be quite poor, with a median quality score of 2 out of 7 (range 1-7), indicating that the majority of the reviews had major methodological flaws. Some of the typical methodological problems with these reviews include: failure to carry out a comprehensive search, failure to avoid bias in selection of studies, failure to appropriately assess methodological quality, and failure to substantiate decisions to combine or not combine studies.

4.2.2 Summary of Included Systematic Reviews:

Buntinx and colleagues[72] undertook a review of computer-based evidence delivery systems that influence diagnostic and preventive performance of clinicians in an inpatient setting. They examined the effect of these systems on physician adherence to medical guidelines. Twenty-six studies (ten randomised controlled trials, eleven before and after studies, and five controlled trials) of computerized and non-computerized feedback and reminder systems fulfilled their inclusion criteria. The authors felt that a quantitative analysis was not feasible given the variety of interventions studied, the lack of precise data reported in each study, and the small number of studies investigating each intervention. Subsequently, an overall qualitative summary including a count of the studies that found an improvement in physician adherence to guidelines was provided. Only two of the 26 studies assessed the efficacy of computerized evidence and specific data from these two studies were not reported. Accordingly, only comments on the efficacy of reminder methods (computerized and non-computerized) were presented; comments could not be made with respect to the effectiveness of computerized reminder systems. Overall, their findings suggest that the use of reminders increase physician adherence to standard guidelines. However, these findings need to be considered in light of the fact that this review had major methodological flaws (i.e., 2/7 on Oxman and

Guyatt index) that introduce bias. Bias was introduced because the authors did not search for unpublished studies, they did not report the quality of the included studies, and they did not have two reviewers independently screen the literature for included studies.

Shiffman and colleagues[76] undertook a review of the effectiveness of computerized guideline implementation systems on influencing clinicians' behaviour and improving patient health outcomes. They identified 25 studies that evaluated guideline implementation systems. These studies varied with respect to their design and the types of outcome variables assessed. Ten studies were time series, nine were randomised controlled trials, one was a controlled clinical trial and the design type was not reported for the remaining five. As a result of this variability the authors did not provide a quantitative analysis. Instead they provided a qualitative summary of each study as well as an overall count of the number of studies that reported a benefit on clinicians' behaviour and patient health outcomes. Guideline adherence by physicians improved in 14 of the 18 studies where it was measured. However, the authors state that the majority of the studies were methodologically flawed. Despite the methodological flaws and heterogeneity in these study designs and outcomes variables, Shiffman et al. conclude that adherence to guidelines can be improved with the use of computerized guideline implementation systems. However, they suggest that studies of the factors affecting success and failure of these systems (e.g., implementation strategies) need to be conducted. The scientific quality of this review was low (i.e., 2/7on Oxman and Gyatt index) since the authors did not complete a comprehensive search of the literature (i.e., did not contact authors), and they did not assess or report the quality of included studies.

In their methodologically sound review (i.e., 7/7 Oxman and Guyatt index), Hunt and colleagues[2] reviewed the efficacy of computer-based clinical decision support systems on changing physician performance and patient health outcomes; this was the second update a previous systematic review. A total of 68 controlled clinical trials fulfilled the inclusion criteria. Given that these studies differed in several respects such as, intervention types, users, and outcome measures, an overall summary statistic was not calculated. Consequently, the authors provided an overall qualitative summary of the studies as well as a tally of the number of studies that reported a statistically significant outcome. Forty-three of the 65 studies that assessed the effects of these systems on the process of care reported an improvement in physician behaviour with the use of these systems. Only six of the 14 studies that investigated the effects of these systems on patient health outcomes found benefits. To explain this result, the authors suggest that many of the studies were too small to exhibit a clinically significant improvement on patient health outcomes. The authors conclude that these systems enhance physician performance for drug dosing, preventive care, and for other medical care, but not for diagnosis. They suggest that additional studies of the effects of these systems on patient health outcomes need to be conducted prior to making any firm conclusions.

Similarly, Montgomery and Fahey's[74] review provides support for the use of computerized clinical decision support systems for enhancing physician performance in the management of hypertension. However, the authors suggest that further studies of patient health outcomes are required. They identified seven studies that fulfilled their selection criteria. The authors did not conduct a meta-analysis because the outcomes were diverse and there were only a small number of trials that examined any one outcome.

Hence, a qualitative summary was provided for each study as well as a count of the number of studies that reported an improvement for each outcome measured. Four of five trials found an increase in patient uptake of blood pressure tests with the use of these systems; two of three studies found an improvement in physician performance with the use of these systems; and, two of six studies found an improvement in patient blood pressure with the use of these systems. According to Oxman and Guyatt some minor methodological flaws (i.e., 4/7 on Oxman and Guyatt index) were introduced in this review since the authors did not complete a comprehensive search (i.e., did not conduct a hand search) of the literature and they did not have two independent reviewers screen the literature for included studies.

In their review of clinical information systems, Balas et al.[70] investigated the impact of numerous computerized information systems on physician performance and patient health outcomes. Ninety-eight randomised controlled trials of various types of systems (i.e., management, diagnostic, treatment, prevention and dosage) fulfilled their eligibility criteria. The authors summarized these trials by providing a count of the number of studies that found a benefit of these systems on physician performance or patient health outcomes. Eighty-three of these 98 studies reported positive results; 76 of 97 that investigated physician performance found a positive effect; 21 of 27 studies that examined patient health outcomes found a benefit. The authors conclude that patient and physician reminders, computer-assisted patient education and computerized treatment planners can improve physician performance and patient health outcomes. There were some major methodological flaws with this review (i.e., 2/7 on Oxman and Guyatt index) that need to be pointed out; they did not provide a list of the criteria used to select studies, two reviewers did not screen for relevant studies, and the quality of included studies was not reported.

Revere and colleagues[75] reviewed the effectiveness of computer generated health behaviour interventions in improving patient behaviour in several clinical areas (e.g., diabetes, migraine, AIDS/HIV). They identified 37 eligible controlled or randomised clinical trials, 33 of which reported statistically significant or improved health behaviours. Consistent with their findings, the authors conclude that computer-generated health behaviour interventions are effective for improving health behaviours of patients. Some bias (i.e., 4/7 on Oxman and Guyatt index) was introduced into the results of this review since the authors only conducted a partial search of the literature (i.e., did not conduct a hand search, did not review reference lists) and they did not identify the types of participants included in their inclusion criteria.

Krishna et al.[73] found similar results in their review of the effectiveness of computerized patient education interventions on the process of care and patient health outcomes. They identified and provided a qualitative summary of 22 randomised controlled trials relevant to their review. All but one of these studies reported a benefit of these systems on patient health status, patient knowledge, and adherence to the best evidence. However, the results of this review may be biased (i.e., 2/7 on Oxman and Guyatt index) since the authors did not complete a comprehensive search of the literature and two independent reviewers did not screen for relevant studies.

Balas et al.[71] undertook a review of randomised controlled trials that evaluated computerized management of diabetes on patient health outcomes. These systems provide educational information to patients and facilitate the storage and transmittal of clinical data between patients and clinicians. They identified 15 eligible studies of which 12 reported positive effects on patient health outcomes. As a result, the authors conclude that the use of computerized management systems is valuable to diabetes management. The scientific quality of this study was low (i.e., 2/7 on Oxman and Guyatt index) because the authors did not perform a comprehensive search of the literature (i.e., did not check reference lists, did not contact authors), they did not have two reviewers screen for relevant studies and they did not state why they did not conduct a meta-analysis.

Colombet et al.[69] reviewed the effectiveness of computerized and non-computerized decision aids for patients with acute chest pain on the process of care and patient health outcomes. Computerized systems were not distinguished from non-computerized systems. Overall, a slight improvement in patient health outcomes was found with the use of these decision aids. Thus, the authors conclude that more trials are needed, as the evidence is limited. This review had extensive methodological problems (i.e., 1/7 on Oxman and Guyatt index). The authors did not complete a comprehensive search of the literature (i.e., did not hand search, did not review reference lists, did not contact authors), they did not state if they assessed the quality of included studies, and they did not report why they chose not to combine the data.

The effect of desktop computers on the consultation process, clinician performance, and patient health outcomes was examined in Sullivan et al's[77] review. The authors provide a summary of the included studies and a count of the number of studies reporting an improvement for each of the outcomes. They identified 30 relevant studies; all 21 studies that examined clinician performance showed an improvement; one of three studies that examined patient health outcomes reported a positive effect. Therefore, Sullivan et al. conclude that using computers in consultation may improve physician performance but more studies are required to assess the effects on patient health outcomes. As a result of the limited literature search conducted and not having two reviewers screen for relevant studies the scientific quality of this study was low (i.e., 2/7 Oxman and Guyatt index). Thus the results of this review are likely to be biased.

Chapter 5: Discussion

This investigation revealed many studies that provide evidence for the use of computer-based health evidence delivery systems for enhancing the process of care by health care providers and patients. However, one must consider this finding in light of the question that was asked when we evaluated these systems. We asked if the "average" computer-based health evidence delivery system "could" work, not whether a particular system "will" work. Thus this review provides evidence that these systems "can" work, however further research is required to determine which systems work best or the factors that distinguish superior from inferior systems. The descriptive analysis was intended to provide insight into the features/factors that distinguished successful from unsuccessful systems and thus to provide direction for further research. Only hypotheses can be made until these factors are thoroughly evaluated.

Seven of the eight systematic reviews that investigated use of computer-based evidence delivery systems found they enhanced provider/patient behavior[2 69-71 73-76]. This is supported by the findings of our meta-analysis that shows computer-based health evidence delivery systems significantly improved the process of care. Although the results of our meta-analysis were significant, the observed difference between the intervention and control groups was small[102] (i.e., SMD 0.14). It is possible that the small difference observed is a consequence of the variability among the results of the individual studies. Some studies showed large differences between the intervention and control groups, whereas other studies found small or no differences. For example, Christakis et al.[32] found that providers changed their prescribing patterns with a system that provided relevant evidence at the point of care; whereas, Overhage et al.[64] did not find providers increased the provision of preventive care with the use of a system that provides reminders (without explicit evidence). The statistical heterogeneity or variability among the findings of these studies is likely a result of one of several differences between the studies such as: the intervention studied (e.g., goal of intervention, format of evidence, interface, etc.), the methodological quality, or the outcomes measured. Thus, variables such as the format of evidence presentation (explicit evidence versus reminders) or the degree of the system's specialization (general medicine versus diabetes care) may contribute to its effectiveness and need to be investigated further. When we pool data from studies that investigate weaker systems with studies that investigate superior systems, the overall estimate may become diluted.

The use of computer based evidence delivery systems was not found to enhance patient health outcomes. In fact, there was basically no difference (SMD –0.02) in patient health outcomes between the intervention and control groups. However, four of the eight systematic reviews that examined the effects of these systems on patient health outcomes documented a benefit[70 71 73 75]. Thus, the findings appear to be mixed. On the whole, few studies have investigated the effect of computer-based evidence delivery systems on patient health outcomes and only a small number of these were able to exhibit a benefit. It is possible we did not find an overall effect of these systems on patient health outcomes because most of these studies were too small to detect a clinically significant benefit and a great deal of variability existed among these studies. Additionally, to have an effect on patient health outcomes, these systems must have an effect on the process of care. Thus, as Hunt et al.[96] suggest, it may be too early to investigate patient health outcomes. The effect of these systems on the process of care needs to be enhanced prior to investigating their effect on patient health outcomes. Nevertheless, it should be noted that it is not always necessary to evaluate patient health outcomes when evaluating these systems. For example, as long as there is evidence concerning the value of a specific procedure /behavior (quitting smoking) it is quite appropriate to use process of care (whether or not the person quit smoking) as a surrogate for patient health outcomes (cancer). In fact, it is often not practical to measure patient health outcomes and in cases where a surrogate is appropriate one should be used. However, it is imperative that an appropriate outcome is chosen when assessing these systems.

Although we were unable to provide evidence that the use of computer-based health evidence delivery systems enhances patient health outcomes it is worth noting that some studies found a benefit. For example, McCowan et al. found the use of an asthma decision support system that presented providers with management recommendations and feedback improved their patients' asthma[7]. Similarly, Rubenstein et al. found the use of a system that presented management recommendations and feedback about patient status to providers increased the patient's functional status[65]. These two studies are worth considering because they investigated systems that differed from the majority in that these two systems provided feedback to the user. It follows, then, that one can speculate there are factors, such as feedback, that are key to having a successful system. This speculation is supported by the findings of Lobach et al. that show systems that provide feedback improve adherence to the system's recommendations[103].

Several studies assessed knowledge acquisition as one of their main outcome variables. It was therefore decided, post hoc, to evaluate the effect of these systems on knowledge acquisition. When knowledge was measured as a dichotomous variable, the systems did not exhibit an effect on the user's knowledge. However, only two of the ten studies that assessed knowledge assessed it as a dichotomous variable. Hence, this may be the result of low power. When the continuous and dichotomous knowledge outcomes were combined, the use of computer-based health evidence delivery systems was found to improve the acquisition of knowledge. According to Lomas'[104] coordinated implementation model, awareness (dissemination) of new knowledge is the first step in the process of changing behaviour. In line with this model we can speculate that these systems are increasing the user's awareness of new knowledge thereby contributing to the process of behaviour change but are not able to effect behavioural change in and of themselves. Instead, they are a precondition to the next step: implementation. This involves identifying and overcoming the inappropriate barriers to using the acquired knowledge.

5.1 Limitations

A potential weakness of this review results from the heterogeneity present among the studies. The studies differed with respect to many factors including: the intervention studied; clinical problems; the specific outcome (e.g., blood pressure, prescribing patterns); sample size; and, follow up. As a result of this heterogeneity, the measure of effect can only be used to answer if the "average" computer-based health evidence delivery system "can" have an effect on the process of care and/or patient health outcomes, not, if they "will" have an effect[105]. A second limitation of this review results from several of the authors not identifying their primary outcome. Additionally, many of the investigators measured more than one variable to represent their primary outcome. Therefore the outcome that best represented the authors goal/hypothesis had to be identified by one of our data extractors. Consequently, there is a chance the most representative variable was not extracted and the study was not represented appropriately. We tried to minimize this bias by having two individuals agree on the outcomes that were extracted.

We are still waiting for seven studies to be translated and for 29 studies to arrive through the University of Alberta's interlibrary loan service. As a result of this and the time constraints for completing this review we were unable to screen all of the potentially relevant documents for this review. However, the bulk of the studies have been assessed; the few that remain are unlikely to change our overall conclusions.

5.2 Authors Conclusions and Recommendations

Several implications and recommendations for future areas of research can be suggested from this review. First, it can be speculated that there are other factors, in addition to the availability of the evidence, which contribute to the lack of compliance with the evidence. This is illustrated by our finding that the alignment of patient/provider behaviour with the evidence was less than optimal despite the use of a computer-based evidence delivery system (e.g., 52% without system; 57% with). Countless reasons may exist for why the uptake of medical evidence is low. Although several of these reasons may be viewed as inappropriate, some may be quite valid. For example, the evidence may be dated or the patient's wishes may not coincide with the evidence. However, the discrepancy is larger than can be accounted for by perfectly valid reasons. This leaves considerable potential for improving the dissemination and use of medical evidence. Consequently, future studies employing a qualitative approach are required to identify the barriers to uptake of medical evidence and, where appropriate, the methods for removing these barriers. Once the barriers are identified and in the appropriate cases removed, further investigations can focus on the effectiveness of these systems; studies for which randomised controlled trials are the most valid.

There was substantial variability among the types of interventions investigated. Some systems were designed to assist patients with managing diabetes; others were designed to assist health care providers with prescribing for otitis media. Some systems were designed for a specific disease (AIDS)[40 106] whereas other systems were designed for more general purposes (providing preventive actions)[35]. Furthermore, some systems provided explicit evidence to the provider while others only provided a recommendation without the appropriate evidence. In addition, the results of the included studies varied, some found a benefit of using the system whereas others did not. Overall, we were unable to conclusively identify the features that distinguish successful from unsuccessful systems. Few, if any, real patterns emerged when describing the systems, which leads to the suggestion that there may not be one generic system that works in every environment. It may be that each system has to be designed for and evaluated in the environment where it will be implemented. However, there may be some factors that are imperative to a system's success in every setting and other factors that make a system successful in one environment and unsuccessful in another. Thus future research needs to focus on identifying the factors that distinguish successful from unsuccessful systems. This information will prove key to developing and implementing computer based evidence delivery systems in the future.

References

1. Sackett DL, Straus SE, Richardson WS, Rosenberg W, Haynes RB. Evidence-Based Medicine: How to practice and teach EBM. 2nd edition. London, England: Churchill Livingstone, 2000.

2. Hunt DL, Haynes RB, Hanna SE, Smith K. Effects of computer-based clinical decision support systems on physician performance and patient outcomes: a systematic review. [see comments]. JAMA 1998; 280(15):1339-46.

3. Eddy T, Morris A. Decision support systems for management of mechanical ventilation. Respiratory Care 1996; 41:327-38.

4. Braden B, Corritore C, McNees P. Computerized Decision Support Systems: Implications for Practice. Nursing Informatics 1997; 46:300-4.

5. Shortliffe E, Perreault L, Fagan L, Wiederhold G. Medical Informatics: Computer Applications in Health Care. Reading, Massachusetts: Wesley Publishing company, 1990.

6. Vissers MC, Hasman A, van der Linden C. Protocol processing system (ProtoVIEW) to support residents at the emergency ward. Computer Methods & Programs in Biomedicine 1995; 48:53-8.

7. McCowan C, Neville RG, Ricketts IW, Warner FC, Hoskins G, Thomas GE. Lessons from a randomised controlled trial designed to evaluate computer decision support software to improve the management of asthma. Medical Informatics and the Internet in Medicine 2001; 26 (3):191-201.

8. Lobach DF HW. Development and evaluation of a Computer-Assisted Management Protocol (CAMP): improved compliance with care guidelines for diabetes mellitus. Proceedings - the Annual Symposium on Computer Applications in Medical Care 1994; 787-91p. 1994.

9. Licciardone J , Herron K, Clark AJ, Squires D. Clinic-based health information web site for international travellers (letter). JAMA 1998; 280:1310.

10. Gustafson DH , Hawkins R, Pingree S *et al*. Effect of computer support on younger women with breast cancer. Journal of General Internal Medicine 2001; 16(7):435-45.

11. Homer C, Susskind O, Alpert H *et al*. An evaluation of an innovative multimedia educational software program for asthma management: Report of a randomised, controlled trial. Pediatrics 2000; 106:210-5.

12. O'Connor A, Tugwell P, Wells G *et al*. Randomized trial of a portable, self-administered decision aid for postmenopausal women considering long-term

preventive hormone therapy. Medical Decision Making. 1998; 18:295-303.

13. Lynch J, Smith G, Hillemeier M, Shaw M, Raghunathan T, Kaplan G. Income inequality, the psychosocial environment, and health: comparisons of wealthy nations. Lancet 2001; 358:194-200.

14. McDonald CHSSDTWCSWMetal. Reminders to Physicians from an Introspective Computer Medical Record
A two-year randomized trial. 100. 1984:130-8.

15. McDonald CWGMG. Physician Response to Computer Reminders. 244. 1980:1579-81.

16. Tierney WM, McDonald CJ, Hui SL, Martin DK. Computer predictions of abnormal test results. Effects on outpatient testing. JAMA 1988; 259(8):1194-8.

17. McDonald C. Use of a Computer to Detect and Respond to Clinical Events: Its Effect on Clinician Behavior. 84. 1976:162-7.

18. Coe FNEOSTAPT. Treatment of Hypertension by Computer and Physician -- A Prospective Controlled Study. 30. 1977:81-92.

19. Wetstone SSTVRPMRN. Evaluation of a Computer Based Education Lesson for Patients with Rheumatoid Arthritis. 15. 1985:907-12.

20. White KS, Lindsay A, Pryor TA, Brown WF, Walsh K. Application of a computerized medical decision-making process to the problem of digoxin intoxication. J Am Coll Cardiol 1984; 4(3):571-6.

21. Rogers JL, Haring OM, Goetz JP. Changes in patient attitudes following the implementation of a medical information system. QRB Qual Rev Bull 1984; 10(3):65-74.

22. Rubin DH, Leventhal JM, Sadock RT *et al*. Educational intervention by computer in childhood asthma: a randomized clinical trial testing the use of a new teaching intervention in childhood asthma. Pediatrics 1986; 77(1):1-10.

23. Rogers JL, Haring OM, Wortman PM, Watson RA, Goetz JP. Medical information systems: assessing impact in the areas of hypertension, obesity and renal disease. Med Care 1982; 20(1):63-74.

24. Rogers JL, Haring OM. The impact of a computerized medical record summary system on incidence and length of hospitalization. Med Care 1979; 17(6):618-30.

25. Chase CR, Vacek PM, Shinozaki T, Giard AM, Ashikaga T. Medical information management: improving the transfer of research results to presurgical

evaluation. Med Care 1983; 21(4):410-24.

26. Andrewes DG, O'Connor P, Mulder C *et al*. Computerised psychoeducation for patients with eating disorders. Australian & New Zealand Journal of Psychiatry 1996; 30(4):492-7.

27. Barry MJ, Cherkin DC, Chang Y, Fowler FJJr, Skates S. A randomized trial of a multimedia shared decision-making program for men facing a treatment decision for benign prostatic hyperplasia. Disease Management & Clinical Outcomes 1997; 1(1):5-14.

28. Bass DM, McClendon MJ, Brennan PF, McCarthy C. The buffering effect of a computer support network on caregiver strain. Journal of Aging & Health 1998; 10(1):20-43.

29. Brennan PF, Moore SM, Smyth KA. The effects of a special computer network on caregivers of persons with Alzheimer's disease. Nursing Research 1995; 44(3):166-72.

30. Cannon DS, Allen SN. A comparison of the effects of computer and manual reminders on compliance with a mental health clinical practice guideline. Journal of the American Medical Informatics Association 2000; 7(2):196-203.

31. Casper GR, Calvitti A, Brennan PF, Overholt JL. ComputerLink: the impact of a computer network on Alzheimer's caregivers' decision-making confidence and skill. Medinfo 1995; 8 Pt 2:1546.

32. Christakis DA, Zimmerman FJ, Wright JA *et al*. A randomized controlled trial of point-of-care evidence to improve the antibiotic prescribing practices for otitis media in children. Pediatrics 2001; 107(2):E15.

33. Dayton CS, Ferguson JS, Hornick DB, Peterson MW. Evaluation of an Internet-based decision-support system for applying the ATS/CDC guidelines for tuberculosis preventive therapy. [see comments]. Medical Decision Making 2000; 20(1):1-6.

34. Demakis JG, Beauchamp C, Cull WL *et al*. Title Improving residents' compliance with standards of ambulatory care: results from the VA Cooperative Study on Computerized Reminders. JAMA 2000; 284(11):1411-6.

35. Dexter PR, Perkins S, Overhage JM, Maharry K, Kohler RB, McDonald CJ. A computerized reminder system to increase the use of preventive care for hospitalized patients. [see comments]. New England Journal of Medicine 2001; 345(13):965-70.

36. Edworthy SM, Devins GM. Improving medication adherence through patient education distinguishing between appropriate and inappropriate utilization.

Journal of Rheumatology 1999; 26(8):1793-801.

37. Evans RS, Classen DC, Pestotnik SL, Lundsgaarde HP, Burke JP. Improving empiric antibiotic selection using computer decision support. Archives of Internal Medicine 1994; 154(8):878-84.

38. Glasgow RE, Toobert DJ, Hampson SE. Effects of a brief office-based intervention to facilitate diabetes dietary self-management. Diabetes Care 1996; 19(8):835-42.

39. Graham W, Smith P, Kamal A, Fitzmaurice A, Smith N, Hamilton N. Randomised controlled trial comparing effectiveness of touch screen system with leaflet for providing women with information on prenatal tests... including commentary by Wyatt J. BMJ 2000; 320(7228):155-60.

40. Gustafson DH , Hawkins R, Boberg E *et al*. Impact of a patient-centered, computer-based health information/support system. American Journal of Preventive Medicine 1999; 16(1):1-9.

41. Hetlevik I, Holmen J, Kruger O, Kristensen P, Iversen H, Furuseth K. Implementing clinical guidelines in the treatment of diabetes mellitus in general practice. Evaluation of effort, process, and patient outcome related to implementation of a computer-based decision support system. International Journal of Technology Assessment in Health Care 2000; 16(1):210-27.

42. Horan PP, Yarborough MC, Besigel G, Carlson DR. Computer-assisted self-control of diabetes by adolescents. Diabetes Educator 1990; 16(3):205-11.

43. Litzelman DK , Dittus RS, Miller ME, Tierney WM. Requiring physicians to respond to computerized reminders improves their compliance with preventive care protocols. Journal of General Internal Medicine 1993; 8(6):311-7.

44. Lobach DF, Hammond WE. Computerized decision support based on a clinical practice guideline improves compliance with care standards. American Journal of Medicine 1997; 102(1):89-98.

45. McPhee SJ, Bird JA, Fordham D, Rodnick JE, Osborn EH. Promoting cancer prevention activities by primary care physicians. Results of a randomized, controlled trial. JAMA 1991; 266(4):538-44.

46. Montgomery AA, Fahey T, Peters TJ, MacIntosh C, Sharp SJ. Evaluation of computer based clinical decision support system and risk chart for management of hypertension in primary care: randomised controlled trial. BMJ 2000; 320(7236):686-90.

47. Nilasena DS, Lincoln MJ. A computer-generated reminder system improves

physician compliance with diabetes preventive care guidelines. Proceedings - the Annual Symposium on Computer Applications in Medical Care 1995; 640-5.

48. Fihn SD, McDonell MB, Vermes D *et al*. A computerized intervention to improve timing of outpatient follow-up: a multicenter randomized trial in patients treated with warfarin. National Consortium of Anticoagulation Clinics. Journal of General Internal Medicine 1994; 9(3):131-9.

49. Rossi RA, Every NR. A computerized intervention to decrease the use of calcium channel blockers in hypertension. Journal of General Internal Medicine 1997; 12(11):672-8.

50. Shegog R, Bartholomew LK, Parcel GS *et al*. Impact of a computerassisted education program on factors related to asthma self-management behavior. Journal of the American Medical Informatics Association 2001; 8(1):49-61.

51. Shojania KG, Yokoe D, Platt R, Fiskio J, Ma'luf N, Bates DW. Reducing vancomycin use utilizing a computer guideline: results of a randomized controlled trial [see comments]. Journal of the American Medical Informatics Association 1998; 5(6):554-62.

52. Turnin MC, Beddok RH, Clottes JP *et al*. Telematic expert system Diabeto. New tool for diet self-monitoring for diabetic patients. Diabetes Care 1992; 15(2):204-12.

53. Vissers MC, Hasman A, van der Linden CJ. Impact of a protocol processing system (ProtoVIEW) on clinical behaviour of residents and treatment. International Journal of Bio-Medical Computing 1996; 42(1-2):143-50.

54. Williams RB, Boles M, Johnson RE. A patient-initiated system for preventive health care. A randomized trial in community-based primary care practices. [see comments]. Archives of Family Medicine 1998; 7(4):338-45.

55. Alterman AI BT. Videotape versus computer interactive education in alcoholic and nonalcoholic controls. Alcoholism: Clinical & Experimental Research 1991; 15(1):39-44.

56. Ben Said M. A comparative study between a computer-aided education (ISIS) and habitual education techniques for hypertensive patients. Proceedings - the Annual Symposium on Computer Applications in Medical Care 1994; 10-4p. 1994.

57. Delichatsios HK FRG, Kelley H. Randomized trial of a "talking computer" to improve adults' eating habits. American Journal of Health Promotion 2001; 15(4):215-24.

58. Gustafson DH HRBEBEP. The use and impact of a computer-based support system

for people living with AIDS and HIV infection. Proceedings - the Annual Symposium on Computer Applications in Medical Care 1994; 604-8p. 1994.

59. Hetlevik I, Holmen J, Kruger O. Implementing clinical guidelines in the treatment of hypertension in general practice: Evaluation of patient outcome related to implementation of a computer-based clinical decision support system. Scandinavian Journal of Primary Health Care 1999; 17(1):35-40.

60. Hobbs FD DBC . A prospective controlled trial of computerized decision support for lipid management in primary care. Family Practice 1996; 13(2):133-7.

61. Medow MA, Wilt TJ, Dysken S, Hillson SD, Woods S, Borowsky SJ. Effect of written and computerized decision support aids for the US Agency for Health Care Policy and Research depression guidelines on the evaluation of hypothetical clinical scenarios. Medical Decision Making 2001; 21(5):344-56.

62. Rhodes KV LDSCHDRML. Better health while you wait: a controlled trial of a computer-based intervention for screening and health promotion in the emergency department. Annals of Emergency Medicine 2001; 37(3):284-91.

63. Wellwood J, Johannessen S, Spiegelhalter DJ. How does computer-aided diagnosis improve the management of acute abdominal pain? Ann R Coll Surg Engl 1992; 74(1):40-6.

64. Overhage JM, Tierney WM, McDonald CJ. Computer reminders to implement preventive care guidelines for hospitalized patients. Archives of Internal Medicine 1996; 156(14):1551-6.

65. Rubenstein LV, McCoy JM, Cope DW *et al*. Improving patient quality of life with feedback to physicians about functional status. J Gen Intern Med 1995; 10(11):607-14.

66. Overhage JM, Tierney WM, Zhou XH, McDonald CJ. A randomized trial of "corollary orders" to prevent errors of omission. J Am Med Inform Assoc 1997; 4(5):364-75.

67. Wheeler LA, Wheeler ML, Ours P, Swider C. Evaluation of computer-based diet education in persons with diabetes mellitus and limited educational background. Diabetes Care 1985; 8(6):537-44.

68. Petrucci K, Petrucci P, Canfield K, McCormick KA, Kjerulff K, Parks P. Evaluation of UNIS: Urological Nursing Information Systems. Proc Annu Symp Comput Appl Med Care 1991; 43-7.

69. Colombet ICGJMDP. Decision aids for triage of patients with chest pain: a systematic review of field evaluation studies. 1999:721-5.

70. Balas EA, Austin SM, Mitchell JA, Ewigman BG, Bopp KD, Brown GD. The clinical value of computerized information services. A review of 98 randomized clinical trials. Archives of Family Medicine 1996; 5(5):271-8.

71. Balas EA, Boren SA, Griffing G. Computerized management of diabetes: a synthesis of controlled trials. Proceedings/AMIA Annual Symposium 1998; 295-9.

72. Buntinx F, Winkens R, Grol R, Knottnerus JA. Influencing diagnostic and preventive performance in ambulatory care by feedback and reminders. A review. Fam Pract 1993; 10(2):219-28.

73. Krishna S, Balas EA, Spencer DC, Griffin JZ, Boren SA. Clinical trials of interactive computerized patient education: implications for family practice. Journal of Family Practice 1997; 45(1):25-33.

74. Montgomery AA, Fahey T. A systematic review of the use of computers in the management of hypertension. Journal of Epidemiology & Community Health 1998; 52(8):520-5.

75. Revere D, Dunbar PJ. Review of computer-generated outpatient health behavior interventions: clinical encounters "in absentia". Journal of the American Medical Informatics Association 2001; 8(1):62-79.

76. Shiffman RN, Liaw Y, Brandt CA, Corb GJ. Computer-based guideline implementation systems: a systematic review of functionality and effectiveness. Journal of the American Medical Informatics Association 1999; 6(2):104-14.

77. Sullivan F, Mitchell E. Has general practitioner computing made a difference to patient care? A systematic review of published reports. BMJ 1995; 311(7009):848-52.

78. Mulrow C. Rationale for sytematic reviews. British Medical Journal 1997; 309:597-9.

79. Jadad AR, Moore RA, Carroll D *et al*. Assessing the quality of reports of randomized clinical trials: is blinding necessary. Control Clin Trials 1996; 17(1):1-12.

80. Schulz KF, Chalmers I, Hayes RJ, Altman DG. Empirical evidence of bias. Dimensions of methodological quality associated with estimates of treatment effects in controlled trial. JAMA 1995; 273(5):408-12.

81. Oxman A, Guyatt GH. Validation of an index of the quality of review articles. J Clin Epidemiol 1991; 44:1271-8.

82. Stata Corporation, inventor. 2001

83. Hasselbald V, Hedges LV. Meta-Analysis of screening and diagnostic tests. Psychological Bulletin 1995; 117:167-78.

84. Hedges LV, Olkin I. Statistical Methods for Meta-Analysis. Academic Press, Inc., 1985.

85. Simes RJ. Publication Bias: The case for an international registry of clinical trials. Journla of Clinical Oncology 1986; 4:1529-41.

86. Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. Biometrics 1994; 50 :1088-101.

87. Egger M, Smith GD, Schneider M, Minder C . Bias in meta-analysis detected by a simple, graphical test. . British Medical Journal 1997; 315:629-34.

88. Duval S, Tweedie R . Trim and fill: A simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. Biometrics 2001; 56:455-63.

89. Cannon DS, Allen SN. A comparison of the effects of computer and manual reminders on compliance with a mental health clinical practice guideline. Journal of the American Medical Informatics Association 2000; 7(2):196-203.

90. Hetlevik I, Holmen J, Kruger O, Kristensen P, Iversen H, Furuseth K. Implementing clinical guidelines in the treatment of diabetes mellitus in general practice. Evaluation of effort, process, and patient outcome related to implementation of a computer-based decision support system. International Journal of Technology Assessment in Health Care 2000; 16(1):210-27.

91. Hetlevik I, Holmen J, Kruger O. Implementing clinical guidelines in the treatment of hypertension in general practice: Evaluation of patient outcome related to implementation of a computer-based clinical decision support system. Scandinavian Journal of Primary Health Care 1999; 17(1):35-40.

92. Medow MA, Wilt TJ, Dysken S, Hillson SD, Woods S, Borowsky SJ. Effect of written and computerized decision support aids for the US Agency for Health Care Policy and Research depression guidelines on the evaluation of hypothetical clinical scenarios. Medical Decision Making 2001; 21(5):344-56.

93. Wellwood J, Johannessen S, Spiegelhalter DJ. How does computer-aided diagnosis improve the management of acute abdominal pain? Ann R Coll Surg Engl 1992; 74(1):40-6.

94. Wetstone SSTVRPMRN. Evaluation of a Computer Based Education Lesson for Patients with Rheumatoid Arthritis. 15. 1985:907-12.

95. White KS, Lindsay A, Pryor TA, Brown WF, Walsh K. Application of a computerized medical decision-making process to the problem of digoxin intoxication. J Am Coll Cardiol 1984; 4(3):571-6.

96. Hunt DL, Haynes RB, Hanna SE, Smith K. Effects of computer-based clinical decision support systems on physician performance and patient outcomes: a systematic review. [see comments]. JAMA 1998; 280(15):1339-46.

97. Shegog R, Bartholomew LK, Parcel GS *et al*. Impact of a computerassisted education program on factors related to asthma self-management behavior. Journal of the American Medical Informatics Association 2001; 8(1):49-61.

98. Turnin MC, Beddok RH, Clottes JP *et al*. Telematic expert system Diabeto. New tool for diet self-monitoring for diabetic patients. Diabetes Care 1992; 15(2):204-12.

99. Ben Said M. A comparative study between a computer-aided education (ISIS) and habitual education techniques for hypertensive patients. Proceedings - the Annual Symposium on Computer Applications in Medical Care 1994; 10-4p. 1994.

100. Petrucci K, Petrucci P, Canfield K, McCormick KA, Kjerulff K, Parks P. Evaluation of UNIS: Urological Nursing Information Systems. Proc Annu Symp Comput Appl Med Care 1991; 43-7.

101. Wheeler LA, Wheeler ML, Ours P, Swider C. Evaluation of computer-based diet education in persons with diabetes mellitus and limited educational background. Diabetes Care 1985; 8(6):537-44.

102. Cohen J. Statistical Power ANalysis for the Behavioral Sciences. 2 edition. Hillsdale, New Jersey: Lawrence Erlbaum Associates, 1988.

103. Lobach DF. Electronically distributed, computer-generated, individualized feedback enhances the use of a computerized practice guideline. Proceedings/AMIA Annual Fall Symposium 1996; 493-7.

104. Lomas J. Diffusion, Dissemination, and Implementation: Who should do what? Annals of the New York Academy of Science 1993; 703:226-35.

105. Bailey KR. Inter-study differences: How should they influence the interpretation and analysis of results? Statistics in Medicine. 1987; 6:351-8.

106. Gustafson D , McTavish F, Hawkins R *et al*. Computer support for elderly women iwth breast cancer (letter). 1998; 280:1305.

Appendix A: Search Strategies

MEDLINE

1 comput$.mp.
2 internet/
3 medline/
4 exp databases/
5 embase.mp.
6 exp educational technology/
7 tool$.mp.
8 "support system$".mp.
9 or/1-8
10 decision$.mp.
11 9 and 10
12 medical informatics/
13 medical informatics applications/
14 decision making, computer-assisted/
15 diagnosis, computer-assisted/
16 therapy, computer-assisted/
17 drug therapy, computer-assisted/
18 "information storage and retrieval"/
19 decision support systems, clinical/
20 reminder systems/
21 medical informatics computing/
22 clinical decision aid$.mp.
23 (computer adj (assisted or aid$ or tool$ or delivery or evidence$ or "patient education")).mp. [mp=title, abstract, registry number word, mesh subject heading]
24 (interactive adj (comput$ or web$)).mp.
25 or/12-24
26 point of care$.mp.
27 bedside$.mp.
28 26 or 27
29 evidence$.mp.
30 28 and 29
31 9 and 29
32 or/11,25,30-31
33 random$.mp.
34 systematic$.mp.
35 meta-anal$.mp.
36 metaanal$.mp.
37 overview$.mp.
38 or/33-37
39 32 and 38
40 animal$.mp.
41 39 not 40

42 limit 41 to yr=1990-2002
43 limit 32 to (controlled clinical trial or meta analysis or randomized controlled trial)
44 43 not 40
45 limit 44 to yr=1990-2002

EMBASE

1 comput$.mp.
2 internet/
3 medline.mp.
4 medical information/
5 data base/
6 embase.mp.
7 educational technology/
8 tool$.mp.
9 support system$.mp.
10 or/1-9
11 decision$.mp.
12 10 and 11
13 information science/
14 decision making, computer-assisted/
15 decision support systems, clinical/
16 information retrieval/
17 computer assisted diagnosis/
18 computer assisted drug therapy/
19 computer assisted therapy/
20 clinical decision aid$.mp.
21 (computer adj (assisted or aid$ or deliver$ or evidence$ or “patient education”)).mp.
22 (interactive adj (comput$ or web$)).mp.
23 or/11-22
24 point of care$.mp.
25 bedside$.mp.
26 24 or 25
27 evidence$.mp.
28 26 and 27
29 12 and 27
30 or/12,23,28-29
31 random$.mp.
32 systematic$.mp.
33 overview$.mp.
34 meta anal$.mp.
35 metaanal$.mp.
36 meta-anal$.mp.
37 or/31-36
38 30 and 37
39 animal$.mp.

40 38 not 39
41 limit 40 to yr=1990-2002

CINAHL

1 comput$.mp.
2 internet/
3 medline/
4 exp databases/
5 embase/
6 educational technology/
7 tool$.mp.
8 “support system”.mp.
9 or/1-8
10 decision$.mp.
11 9 and 10
12 medical informatics/
13 decision making, computer-assisted/
14 diagnosis, computer-assisted/
15 exp therapy, computer-assisted/
16 clinical information systems/
17 decision support systems, clinical/
18 reminder systems/
19 “clinical decision aid$”.mp.
20 (computer adj (assisted or aid$ or tool$ or delivery or evidence$ or “patient education”)).mp. [mp=title, cinahl subject heading, abstract, instrumentation]
21 (interactive adj (comput$ or web$)).mp.
22 or/12-21
23 point of care$.mp.
24 bedside$.mp.
25 patient bedside/
26 or/23-25
27 evidence$.mp.
28 26 and 27
29 9 and 27
30 or/11,22,28-29
31 random$.mp.
32 systematic$.mp.
33 meta-anal$.mp.
34 metaanal$.mp.
35 overview$.mp.
36 or/31-35
37 30 and 36
38 animal$.mp.
39 37 not 38
40 limit 39 to yr=1990-2002

Cochrane Controlled Trials Register (CENTRAL/CCTR)

1 comput$.mp.
2 internet.mp.
3 medline.mp.
4 database$.mp.
5 embase.mp.
6 educational technology.mp.
7 tool$.mp.
8 “support system$”.mp.
9 or/1-8
10 decision$.mp.
11 9 and 10
12 medical informatics.mp.
13 (“computer-assisted” adj (decision$ or therapy or diagnosis or “drug therapy”)).mp.
14 “reminder system$”.mp.
15 clinical decision aid$.mp.
16 (computer adj (assisted or aid$ or tool$ or delivery or evidence$ or “patient education”)).mp.
17 (interactive adj (comput$ or web$)).mp.
18 or/12-17
19 “point of care$”.mp.
20 bedside$.mp.
21 19 or 20
22 evidence$.mp.
23 21 and 22
24 9 and 22
25 or/11,18,23-24

Web of Science

computer same (“support system*” OR “DECISION MAKING” OR DIAGNOSIS OR THERAPY OR “DECISION AID*” OR MEDLINE OR EDUCATION OR “POINT OF CARE” OR BEDSIDE* OR EVIDENCE*) AND (RANDOM* OR SYSTEMATIC* OR “META ANAL*” OR OVERVIEW)

Effective Practice and Organization of Care Trial Registry

Search strategy used was: comput* searched in all fields (title abstract MeSH or equivalent subject headings & interventions) and confined to those studies coded with a professional-oriented intervention.

Appendix B: Computer-based health evidence software companies contacted for grey literature

3MS HIS
A4 health care systems
Accordant
Accuimage Diagnostic
achieve health care information systems
Allen systems group
allmedia solutions
□ando corp
Apache Medical systems
Apelon
Aries system corp
Arkansas Data services
ARMS Medical Resource Management
Asterion.com
Automating peripherals
Avio
AVL
Axonal Health solutions
Brio Technology
Cancerfacts.com
care is #1
care management science
caredata.com
carefacts information systems inc.
careflow/net inc.
carekeeper software inc.
Carescience
caresteps
caretools inc.
carewise
cedaron
cerner corp
certus corp
chart care inc
cirus group
clinical dynamics
cognos
□andom computer corp
corechange
cpm corp
CPSI
csc's healthcare group
cybear
datawatch
delair systems
□andom systems
dennis HMS

doctor quality
Eclipsys corp
EDS
eHealth contracts
eHealth direct
eldorado computing
electronic health care systems
eMD's
entre technology group
ePhysician
epic systems corp
erisco managed care technologies
esprit health
EXCELCARE inc
Experior corp
FACTS service
First databank
GeoAccess
GeoHealth
Global Medic
hanns on software
Hayes Management counselling
HBS International
HCIA
Health care data systems
Health care software
health cast LLL
health cost consultant
health forum AHA
health language inc
health share technologies
HEALTH VISION
healthcare solutions
Healthgrades.com
HealthMeDX inc.
healthwise
IDX Systems
IMPAX medical systems
Infinity medical Systems
infinium
infominers.com
Infopartners inc.
INGENIX
integrated health systems
Integreat concepts
intelihealth
intellidata inc.
intelligent medical objects
interactive business systems
internexsys corp

intramedX
IRP Systems
IVC
JKC Inc.
keane
Key Solutions
kronos
LEXCONX
life masters supported selfcare
link technologia aplicada
M2 information systems
managed care software
manhanttan association
mcKessonHBOC medical management group
MD/Win corp.
mdeverywhere
MECON
MEDai
Medcomsoft
medecision
medibuy.com
medical communication systems inc
medical manager health system
medical systems management
medical telecommunication associated
medicalogic inc.
medifor
medimpact
mediserve information systems
mediware information systems inc
melyx corp
micro4 inc
microanalysis and design
microstrategy
MIDS
MIQS
Mission: accomplished
Narratek inc
NDC health information services
nelson data resources
nuesoft technologies
NYBOR.com
OAO health care solutions
Omnient Corp
Oncall Health care communications
on-line consultant sfotware
oracle corp
organic net
ormed information systmes
park city solutions

patient keeper
payor ID
pegasystems
people soft
per-se technolgies
PhDx systems
Phycom
Physician data network
physmark
picis
pilot software
PKC
plexis healthcare systems inc
Predictive Health care systems
Premier
Prodata systems
prograde technolgies
promodel
provantage health services
provider solutions corp
purkinje
QS1 data systems
Quadax
Quadramed corp
RAM technolgies
□andom & Anders
Research systems
RNA health information system
Rosebud Solutions
SAP America
SAS institute
Saui Technology
SCI soft computer
SEC
Shams group
Simione central
simkin
SMS corp
solution point
space labs medical
spotfire
sweetwater health enterprises
symmetry health data systems
Teams Rehabilitation systems
telemedical.com
teleresults
terahealth
teton data systems
thinkmed
touchpoint software

treage software
□andomi medical
tricord health care systems
USIS health
vasona systems
wang health care information systems
wellmed
wellsoft corp.
windstar technology
world development group
xcare.net

Appendix C: Inclusion/Exclusion form for Randomised Controlled Trials

DATE: dd _____ mm _____ yy _____ REVIEWER: _____ REFERENCE #: ______

1. **DESIGN,**

   included if:

   [ ] RCT
   [ ] Systematic Review of RCT's

   excluded if:

   [ ] not an RCT or SR

10. **INTERVENTION,**

   included if:

   [ ] use of computer-based health evidence (e.g. clinical decision support systems; provider reminders; computer-assisted diagnosis, prognosis, interactive patient education, instruction, therapy; etc.) vs. no use of computer-based health evidence

   excluded if:

   [ ] other intervention

10. **PARTICIPANTS,**

   included if:

   [ ] health care providers
   [ ] health care clients

   excluded if:

   [ ] other

10. **OUTCOMES,**

   included if:

   [ ] objective measure of the process and/or outcome of care (e.g. changes in laboratory test ordering, changes in prescribing patterns, morbidity, changes in patient knowledge and attitudes)

   excluded if:

   [ ] other

5. **FINAL DECISION,**

   [ ] Included (met all inclusion criteria from 1-4)
   [ ] Excluded
   [ ] Can not tell (need more information)

if there is a disagreement between reviewers, final decision:

[ ] Included
[ ] Excluded

Appendix D: Inclusion/Exclusion Form for Systematic Reviews

DATE: dd _____ mm _____ yy _____ REVIEWER: _____ REFERENCE #: ______

10. DESIGN,

included if:

[ ] Systematic Review

excluded if:

[ ] not a SR

10. TOPIC,

included if:

[ ] includes a review of computer-based delivery of health evidence (e.g. clinical decision support systems; computer-assisted diagnosis, prognosis, interactive patient education, etc.)

excluded if:

[ ] other intervention

10. INCLUSION/EXCLUSION,

included if:

[ ] report explicit inclusion/exclusion criteria

excluded if:

[ ] do not report inclusion/exclusion criteria

4. FINAL DECISION,

[ ] Included (met all inclusion criteria from 1-3)
[ ] Excluded
[ ] Can not tell (need more information)

if there is a disagreement between reviewers, final decision:

[ ] Included

[ ] Excluded

Appendix E: Jadad Scale
Quality Assessment for RCT's

JADAD SCORE: circle the appropriate response and total for the final Jadad score
Randomization:

1. Was the study described as being □andomised? 1 = Yes 0 = No
2. Was the method of □andomised□on appropriate? 1 = Yes 0 = No
3. Was the method of □andomised□on inadequate? -1 = Yes 0 = No

Double Blindedness:

4. Was the study described as double-blind? 1 = Yes 0 = No
5. Was the method of double-blinding appropriate? 1 = Yes 0 = No
6. Was the method of double-blinding inadequate? -1 = Yes 0 = No

Withdrawals:

7. Was there an adequate description of withdrawals? 1 = Yes 0 = No

Total Score:

CONCEALMENT OF ALLOCATION: was the method used to conceal the □andomised□on list

[ ] adequate
[ ] inadequate
[ ] unclear

Randomization: specifically stated as □andomised□on, □andomised… Balanced □andomised□on□ are irrelevant.
Appropriate Randomization: must state the source of the number used for □andomised□on e.g., computer generated, unbiased coin toss, random numbers table…
Inadequate Randomization: method is not truly random e.g., consecutively assigned, temporally allocated…
Double Blind: the researcher and participants are unaware of the group assignment
Adequate Double Blinding: the study treatments are identical with respect to their physical properties e.g., double dummy…
Inadequate Double Blinding: study is not truly double blinded
Adequate Description of Withdrawals: participant is either requested to quit the study because they are not following protocol or chooses to do so voluntarily. Authors must also state what treatment arm the individual is participating in during the withdrawal.
Adequate Concealment of Allocation: □andomised□on list is protected. E.g., sealed, opaque envelopes, central □andomised□on…
Inadequate Concealment of Allocation: specifically states that there is no attempt to mask treatment of allocation
Unclear Concealment of Allocation: the concealment of allocation in not described

Appendix F: Oxman and Guyatt's index of the Scientific Quality of Research Overviews

10. Were the search methods used to find evidence (primary studies) on the primary question(s) stated?

NO	☐
PARTIALLY	☐
YES	☐

10. Was the search for evidence reasonably comprehensive?

NO	☐
PARTIALLY	☐
YES	☐

10. Were the criteria used for deciding which studies to include in the review reported?

NO	☐
PARTIALLY	☐
YES	☐

10. Was bias in the selection of articles avoided?

NO	☐
PARTIALLY	☐
YES	☐

10. **Were the criteria used for assessing the validity of the studies that were reviewed reported?**

NO

PARTIALLY

YES

10. **Was the validity of all of the studies referred to in the text assessed using appropriate criteria (either in selecting studies for inclusion or in andomise the studies that are cited)?**

NO

PARTIALLY

YES

10. **Were the methods used to combine the findings of the relevant studies (to reach a conclusion) reported?**

NO

PARTIALLY

YES

10. **Were the findings of the relevant studies combined appropriately relative to the primary question the review addresses?**

NO

PARTIALLY

YES

10. Were the conclusions made by the author(s) supported by the data and/or analysis reported in the review?

NO	
PARTIALLY	
YES	

10. Overall, how would you rate the scientific quality of this review?

Extensive flaws		Major flaws		Minor flaws		Minimal flaws
1	2	3	4	5	6	7

Comments:

Appendix G: Data extraction form for Randomised Controlled Trials

Ref. Number _____ Reviewer _____
Date dd_____ mm_____ yy _____

Study Characteristics

Year of Publication			
Country			
Funding Source	Government	Industry	Other (list)
Study Objectives			
Study Design (e.g. parallel, cross-over, cluster)			
Jadad Score			
Allocation Concealment			
Intention to Treat is stated or implied?	YES	NO	
Intention to Treat is completed	YES	NO	N/A (no losses to follow-up)

Intervention/participant characteristics

Intervention Type (definition)		
Computer Intervention: Active vs. Passive?	ACTIVE	PASSIVE
Comparisons		

Specific use of intervention (e.g. manage diabetes)			
Goal of intervention (e.g. prevention, diagnosis, prescriptions, educator, prognosis, etc.)			
Who uses the intervention? (e.g. physician, nurse, patient etc.)			
Setting (e.g. hospital, clinic etc.)			
Total Sample size			
Contamination (i.e. are the groups treated at the same clinic?)			
Randomisation units (e.g. physicians, nurses, patients, clinics)			
	Intervention 1	Intervention 2	Control
Number of randomised participants/group			
Description/number of losses to follow-up			

Primary Outcome

Definition Of Outcome			
Primary outcome	Stated	Inferred	Randomised (how?)
Type of outcome	COMPLIANCE/ PROCESS	HEALTH STATUS	OTHER
Who does the unit of analysis target? (e.g. physician, nurse, patient, etc.)			
If Dichotomous:	Total Sample Size	Number of Events	
Intervention 1			
Intervention 2			
Control			
If Continuous:	Total Sample Size	Mean	Standard Deviation
Intervention 1			
Intervention 2			
Control			
If Non-parametric:	Total Sample Size	Median	Inter-quartile range
Intervention 1			
Intervention 2			
Control			

Additional Outcome

Definition Of Outcome			
Type of outcome	COMPLIANCE/ PROCESS	HEALTH STATUS	OTHER
Who does the unit of analysis target? (e.g. physician, patient etc.)			
If Dichotomous:			
Intervention 1			
Intervention 2			
Control			
If Continuous:	Total Sample Size	Mean	Standard Deviation
Intervention 1			
Intervention 2			
Control			
If Non-Parametric:	Total Sample Size	Median	Inter-quartile range
Intervention 1			
Intervention 2			
Control			

Conclusions

Authors Conclusions	ENDORSED	UNSURE	NOT ENDORSED
Authors Comments on use, barriers to use or policy issues. (qualitative component)			
Other			

Appendix H: Data Extraction Form for Systematic Reviews

Ref Number _____ Reviewer _____ Date dd _____ mm _____ yy _____

Focus/objective of SR	
Inclusion criteria employed for the SR	
Total number of included studies in SR	
Total number of included studies in SR that investigated computer-based delivery of health evidence	
Type of computer-based interventions investigated (type, for what purpose, specific to what disease? E.g. reminder, prevention, diabetes)	
Main outcomes/results specific to the studies of computer-based interventions	
How many studies of computer-based interventions showed a difference between groups? (Which direction?)	
Author's conclusions with respect to compute-based interventions	

Appendix I: Glossary of Computer-Based Evidence Delivery Systems

First Author	Year	Goal of Intervention	Clinical Area	Intervention
Cannon DS	2000	Diagnosis	Mood Disorders	CaseWalker - generates reminders to screen patients for mood disorder, presents and scores the DSM-IV criteria for Mood disorder and creats patient specific progress notes based on guidelines.
Hetlevik I	2000	Diagnosis	Diabetes, Hypertension, and Hypercholestrolemia	Clinical decision support system - guides doctors in diagnostics, history taking, physical examination additional tests, and treatment. Integrated patient information to guide the doctor in making a diagnosis of hypertension, diabetes, or hypercholesterolemia. Provides recommendations for additional exams, more detailed information such as dietary advice, and decision support.
Hetlevik I	1999	Diagnosis	Diabetes, Hypertension, and Hypercholestrolemia	Clinical decision support system - incorporates clinical guidelines to provide patient specific diagnostic and therapeutic decision support
Medow MA	2001	Diagnosis	Depression	Computerized sysem integrates patient information with guideline based decision rules to provide patient specific diagnostic and therapeutic recommendations.
Wellwood J	1992	Diagnosis	Abdominal Pain	Computer system that integrates patient data to provide possible diagnoses for acute abdominal pain along with the probability for each diagnosis.
Alterman AI	1991	Management	Alcohol Abuse	Computer interactive instructional program provides individualized educational information and feedback.
Andrewes DG	1996	Management	Anorexia/ Bulimia	DIET - Includes a real world scenario. Educational information is then provided followed by test and feedback with information that is not learned repeated.
Ben Said M	1994	Management	Hypertension	ISIS - interactive patient education program. Alternates relaxing interludes with educational messages. The educational component requires the patient to answer questions. The patient is provided with the correct answer and can consult an explanation for each Q&A pair.
Chase CR	1983	Management	Respiratory	Medical Information Management (MIM) - analyzes patient specific data and classifies patients as high risk surgical patients. Provides printout of the history and analysis for high-risk patients.
Coe FL	1977	Management	Hypertension	Applies a treatment algorithm to patient data to suggest possible drug reactions and drug treatment recommendations
Demakis JG	2000	Management	Ambulatory Care	Patient specific reminders - when provider enters patient name all reminders pertaining to that patient are automatically presented in bold letters; each reminder consists of a notification that a specific standard of care can be applied to the patient and a brief rational for the standard is also provided. In addition, a computer-generated summary of the patient's health was placed at the beginning of the patient's chart.
Edworthy SM	1999	Management	Arthritis	Graphically engaging computer program that explains the nature of their medication, the side effects and benefits the patient might expect and the importance of their involvement in treatment decisions.

First Author	Year	Goal of Intervention	Clinical Area	Intervention
Fihn SD	1994	Management	Anticoagulation	Integrated patient information to provide a recommendation for the optimal follow-up up interval for patients taking warfarin
Glasgow RE	1996	Management	Diabetes	A touch screen computer assessment that identifies barriers to dietary self-care. Provides a one-page form that with patient specific feedback on fat intake and barriers to dietary self-care.
Graham W	2000	Management	Prenatal care	Touch screen computerized information system. Patient accesses the information by means of a touch screen display. Menu driven system with educational video clips and voice-overs.
Hobbs FDR	1996	Management	Hyperlipidaemia	Primed system - rule based system that integrates patient datato provide a coronary risk score, offers patient specific advice on appropriate management. In daddition provides detailed information on drug dosages, prescribing, dietary guidelines and specific physical signes.
Horan PP	1990	Management	Diabetes	Diabetes in self-control (DISC) - manages, reviews and stores personal data on blood glucose and other self monitored data; uses this personal data to provide factual and applied diabetes education on diabetes management procedures. Factual information is presented to the user trhough computer-assisted diagetes educaiton modules.
Lobach DF	1997	Management	Diabetes	Computer assisted management protocol (CAMP) - integrates patient data with disease specific guidelines to generate patient specific care recommendations.
McCowan C	2001	Management	Asthma	Asthma Crystal Byte - provides decision support (Feedback and management suggestions) relating to current asthma guidelines and based on the patient data entered at consultation by the user.
McDonald CJ	1980	Management	General Medicine	Applies management rules to patient data to generate reminders for the physician about clinical events that might need corrective action.
McDonald CJ	1976	Management	Diabetes	Regenstrief Medical Record System (RMRS) - generates protocol driven patient specific recommendations that alert clinicians to the existence of and the proper response to clinical events on a printed report.
Montgomery AA	2000	Management	Hypertension	Clinical decision support system - integrates patient specific data to provide the patient's five-year risk of a fatal or non-fatal cardiovascular event.
Nilasena DS	1995	Management	Diabetes	Integrates patient data to provide a health maintenance report and to provide clinical alerts about high-risk aspects of the patient's current profile. For patients with diabetes. This report is placed in the front of the patient's chart prior to the patient's next physician visit

First Author	Year	Goal of Intervention	Clinical Area	Intervention
Overhage JM	1997	Management	General Medicine	Regenstrief Medical Record System (RMRS) - When a physician orders a specific test or treatment a rule-based reminder program analyses the patient data in the medical record and determines if any corollary orders should be provided to monitor/ameliorate the effects of the tests/treatments. The computer then displayed the suggestions on the computer screen. Rules are based on guidelines.
Petrucci K	1992	Management	Incontinence	Urological Nursing Information System (UNIS) - Provides patient specific recommendations to assist nurses caring for elderly incontinent patients.
Rogers JL	1982	Management	Hypertension, obesity, renal disease	Northwestern University computerized medical record summary system (NUCRSS) - provides current information on patient’s problems, identifies omissions in recording of observations, and treatment recommendations and provides recommendations for corrective actions according to selected criteria.
Rogers JL	1984	Management	Outpatient Care	Medical Information System (MIS) - Electronic medical record that provides 8-page summary of patient information. Includes comments and suggestions to the physician concerning deficiencies in the patient's care.
Rogers JL	1979	Management	Inpatient Care	Northwestern University computerized medical record summary system (NUCRSS) - generates 8-page summary for each visit to the clinic. It updates necessary information about the patient, such as the problem list, medications, and result of laboratory tests and also suggests patient specific actions concering the process of care.
Rubenstein LV	1995	Management	Functional status of feedback	Computer generated feedback to physicians about the patient's functional status, the patient's self-reported chief complaint, and problem-specific resource and management suggestions.
Rubin DH	1986	Management	Asthma	Asthma Command - interactive computer game to educate children on asthma management. Players must use their asthma management knowledge to manoeuvre through many obstacles presented in the game.
Shegog R	2001	Management	Asthma	Watch, Discover, Think, and Act (WDTA) - Computer based educational program designed to teach asthma self-management skills to children. Provides tailored self-management education through real world simulations; tutorials; and games.
Turnin MG	1993	Management	Diabetes	Diabeto - computer-assisted diet education system. Individualized computer assisted education and information system to improve self-monitoring of diabetes.
Wetston SL	1985	Management	Arthritis	Computer education system on arthritis that provides factual data, practice solving problems, and patient specific recommendations.
Wheeler LA	1985	Management	Diabetes	Computer Education provides information about the diabetic diet. Integrates patient information with algorithm and database to develop a patient specific meal plan that meets diet requirements. Output includes menus, shopping lists, and weekly average nutritional analysis of the menus.

First Author	Year	Goal of Intervention	Clinical Area	Intervention
White KS	1984	Management	Digoxin Toxicity	Health Evaluation through Logical Processing (HELP) - accesses patient data from the patient database and applies the data to a set of decision criteria to monitor signs and predisposing factors of digoxin intoxication in patients. Prints a patient specific alert that is placed in the patient's chart.
Tierney WM	1988	Prediction	Not Specified	When physician orders a specific diagnostic test the computer analyses patient specific data and displays the probability that the test will show the abnormality that the physician selected as the main one of interest.
Christakis DA	2001	Prescription	Otitis Media	Computerized pop-up messages that convey evidence are generated based on the physician's selection of antibiotic, indication and duration.
Evans RS	1994	Prescription	Infectious diseases	Antibiotic consultant - accesses patient's medical record and integrates patient information with infection information to determine the patient's most likely pathogen. Suggests five antibiotic regimens that are most likely to be effective for all of the pathogens and suggests an appropriate antibiotic regimen.
Rossi RA	1997	Prescription	Hypertension	An automated computer query identifies patients who are prescribed drugs for hypertension. A one-page guideline reminder highlighting the patient's prescription and recommending alternative drugs and doses is provided to the patient's provider.
Shojania KG	1998	Prescription	Infection	Provider order entry system displays guidelines for the appropriate use of vancomycin. Guidelines pop up when physician orders vancomycin for a patient.
Dayton CS	2000	Prevention	Tuberculosis	Internet-based decision support system - integrates patient information with guidelines and provides patient specific recommendations for tuberculosis preventive therapy
Delichatsios HK	2001	Prevention	Diet	Interactive home-based computer system. Functions as an educator and counsellor to assist people with changing health related behaviours. The system asks questions to monitor the individuals behaviour and health conditions and provides education and behavioural reinforcement for targeted health-related behaviours.
Dexter PR	2001	Prevention	General preventive medicine	Computerized order entry system and clinical decision support. The system provides clinical decision support to physicians by means of rule-based reminders. Integrates patient data with guideline-based rules to provide reminders for preventive therapies.
Litzelman DK	1993	Prevention	Cancer	Computerized reminder system that reviews the patient record prior to a scheduled visit and prints a reminder to the physician if specific preventive tests are required. Also provides patient-specific data for each reminder and explains the rule that generated it.
McDonald CJ	1984	Prevention	General Practice	Applies guideline-based rules to patient's electronic medical record and generates printed reminders for patients who require preventive care. These reminders specify the patient's state and the clinical action indicated for that state. In addition, the reminder messages include citations to relevant medical literature.

First Author	Year	Goal of Intervention	Clinical Area	Intervention
McPhee SJ	1991	Prevention	Cancer	Cancer Prevention Reminder System (CPRS) - generates up-to-date reports of each patient's screening, assessment and counselling status as a reminder to perform or obtain the prevention manoeuvres.
Overhage JM	1996	Prevention	Inpatient Care	Regenstrief Medical Record System (RMRS) - analyses patient data in the medical record and identifies preventive care measures for which patients are eligible. Printed recommendations are then placed in the patient's record and recommendations also appear at the bottom of the computer screen when a provider writes orders for the patient.
Rhodes KV	2001	Prevention	Risky Behaviors	Self-administered computer based health risk assessment - patients complete a questionnaire then the computer generates patient-specific health recommendations and provides any additional information requested. The program also generates a one-page summary with the patient's demographic information, major health risks and referral information for the physician.
Williams RB	1998	Prevention	Cancer	Touch sensitive computer system - patient completes computerized questionnaire, then the computer prints out patient-specific chart reminders, chart organizers, order sheets and patient education materials for the physician. Also provides patient-specific prevention recommendations for the physician,
Bass DM	1998	Support	Caregiver Strain	ComputerLink - Support network - provides communication with other caregivers, question and answer facilitated by a nurse, electronic encyclopaedia, and decision support.
Casper GR	1995	Support	Alzheimers disease	ComputerLink - Support network - provides communication with other caregivers, question and answer facilitated by a nurse, electronic encyclopaedia, and decision support.
Flatley-Brennan P	1995	Support	Alzheimers disease	ComputerLink - Support network - provides communication with other caregivers, question and answer facilitated by a nurse, electronic encyclopaedia, and decision support.
Gustafson DH	2001	Support	Breast Cancer	Comprehensive Health Enhancement Support System (CHESS) - integrates eleven services to provide disease specific information, decision-making tools and support services.
Gustafson DH	1998	Support	AIDS/ HIV	Comprehensive Health Enhancement Support System (CHESS) - integrates eleven services to provide disease specific information, decision-making tools and support services. Q&A, instant library, getting help, support, referral dictionary, assessment, decision aid, action plan, discussion group, ask an expert, and personal stories.
Gustafson DH	1994	Support	AIDS/ HIV	Comprehensive Health Enhancement Support System (CHESS) - integrates eleven services to provide disease specific information, decision-making tools and support services. Q&A, instant library, getting help, support, referral dictionary, assessment, decision aid, action plan, discussion group, ask an expert, and personal stories.

First Author	Year	Goal of Intervention	Clinical Area	Intervention
Barry MJ	1997	Treatment	Hyperplasia	Shared decision-making program - Synthesizes video, audio, and computer graphics to provide patient specific information. Patient information is entered into computer and the program is then tailored to the patient.
Vissers MC	1996	Treatment	Trauma	Protocol Information System (ProtoVIEW) - Allows physicians to enter patient data and to retrieve protocol knowledge for treating isolated fractures.

Table 1: Subgroup factors

Subgroup and Sensitivity analysis	Factor Levels
Clinical Subgroups:	
Goal of Intervention	Management, Prevention, Diagnosis, Prescription, Treatment, Support
User of Intervention	Patients, Provider
Type of System	Active, Passive
Setting	Inpatient, Outpatient, Home
Country	North American, Other Countries
Methodology and/or Quality Subgroups:	
Funding	Government, Private, Unclear
Jadad Score	3, less than 3
Allocation Concealment	Adequate, Inadequate, Unclear
Intention-to-Treat	Stated, Not Stated
Contamination	Contaminated, Not Contaminated
Non-Independence	Non-Independent Data, Independent Data
Study Design	Parallel, Cross-Over, (Parallel) Cluster
Sensitivity Analysis:	
Primary Outcome	Primary, Non-Primary
Selection of Primary Outcome	Stated, Inferred, Presented First
Converted Binary Data	Continuous, Originally Binary
Lost to Follow-up	Not applicable
Design Effect for Cluster Studies	Not applicable

Table 2: Reasons for exclusion

First Author	Year	Study Design	Reason for Exclusion
Ageno, W	1998	Randomised Controlled Trial	Dose Calculation
Bacchus, CM	1994	Randomised Controlled Trial	Teaching
Balaguer Santamaria, JA	2001	Randomised Controlled Trial	Dose Calculation
Bankhead, C	2001	Randomised Controlled Trial	Reminder - Administrative
Baren, JM	2001	Randomised Controlled Trial	Reminder - Administrative
Barnett, GO	1983	Randomised Controlled Trial	Reminder - Administrative
Barr, JK	2001	Randomised Controlled Trial	Reminder - Administrative
Bates, DW	1995	Randomised Controlled Trial	No Evidence Delivery
Bates, DW	1998	Randomised Controlled Trial	No Evidence Delivery
Begg, EJ	1989	Randomised Controlled Trial	Dose Calculation
Billipp, SH.	2001	Randomised Controlled Trial	No Evidence Delivery
Bird, JA	1990	Randomised Controlled Trial	Not Computerized
Bogusevicius, A	2002	Randomised Controlled Trial	No Evidence Delivery
Bonevski, B	1999	Randomised Controlled Trial	Not at Point of Care
Boucher, B	1999	Randomised Controlled Trial	Teaching
Brimberry, R.	1988	Randomised Controlled Trial	Reminder - Administrative
Bulpitt, CJ	1976	Randomised Controlled Trial	Administrative
Burack, RC	1997	Randomised Controlled Trial	Reminder - Administrative
Burack, RC	1994	Randomised Controlled Trial	Reminder - Administrative
Burack, RC	1996	Randomised Controlled Trial	Reminder - Administrative

First Author	Year	Study Design	Reason for Exclusion
Campbell, JR	1994	Randomised Controlled Trial	Reminder - Administrative
Casner, PR	1993	Randomised Controlled Trial	Dose Calculation
Chambers, CV	1991	Randomised Controlled Trial	Reminder - Administrative
Chiarelli, F	1990	Randomised Controlled Trial	Dose Calculation
Clark, M	1997	Randomised Controlled Trial	No Evidence Delivery
Darnell, JC	1985	Randomised Controlled Trial	Reminder - Administrative
Demiris, G	2001	Randomised Controlled Trial	Video Conferencing
Dexter, PR	1998	Randomised Controlled Trial	No Evidence Delivery
Dickinson, JC	1981	Randomised Controlled Trial	Teaching
Dini, EF	2000	Randomised Controlled Trial	Reminder - Administrative
East, TD	1999	Randomised Controlled Trial	No Evidence Delivery
Eccles, M	2001	Randomised Controlled Trial	Not Computerized
Fisher, LA	1977	Randomised Controlled Trial	Teaching
Fitzmaurice, DA	2000	Randomised Controlled Trial	Dose Calculation
Fitzmaurice, DA	1996	Randomised Controlled Trial	Dose Calculation
Flanagan, JR	1999	Randomised Controlled Trial	Reminder - Administrative
Frame, PS	1994	Randomised Controlled Trial	Reminder - Administrative
Frances, CG	2001	Randomised Controlled Trial	Not Patient Specific
Ghosh, A	1984	Randomised Controlled Trial	Therapy - no evidence delivery
Ghosh, A	1988	Randomised Controlled Trial	Therapy - no evidence delivery
Halbert, RJ	1999	Randomised Controlled Trial	Reminder - Administrative
Hershey, CO	1988	Randomised Controlled Trial	No Evidence Delivery

First Author	Year	Study Design	Reason for Exclusion
Hershey, CO	1986	Randomised Controlled Trial	No Evidence Delivery
Hickling, K	1988	Randomised Controlled Trial	Dose Calculation
Hillson, SD	1995	Randomised Controlled Trial	No Evidence Delivery
Holmes-Rovner, M	1999	Randomised Controlled Trial	Not Computerized
Hoster, M	1997	Randomised Controlled Trial	No Evidence Delivery
Hwang, HG	1994	Randomised Controlled Trial	Teaching
Jerosch, J	1998	Randomised Controlled Trial	No Evidence Delivery
Kattan, MW	1999	Randomised Controlled Trial	No Evidence Delivery
Krska, J	2001	Randomised Controlled Trial	Not Computerized
Kuperman, GJ	1999	Randomised Controlled Trial	No Evidence Delivery
Larson, EB	1982	Randomised Controlled Trial	Reminder - Administrative
Lewis, G	1996	Randomised Controlled Trial	No Evidence Delivery
Lieu, TA	1997	Randomised Controlled Trial	Reminder - Administrative
Lin, DTC	1990	Randomised Controlled Trial	No Evidence Delivery
Linkins, RW	1994	Randomised Controlled Trial	Reminder - Administrative
Locke, SE	1993	Randomised Controlled Trial	No Evidence Delivery
Lorentz, A	1987	Randomised Controlled Trial	Dose Calculation
Lorig, KR	2002	Randomised Controlled Trial	No Evidence Delivery
Lyon, HC	1991	Randomised Controlled Trial	Teaching
McAlister, NH	1986	Randomised Controlled Trial	Not Computerized
McBride, JS	1999	Randomised Controlled Trial	No Evidence Delivery
McDonald, CJ	1992	Randomised Controlled Trial	Reminder - Administrative

First Author	Year	Study Design	Reason for Exclusion
McDowell, I	1986	Randomised Controlled Trial	Not Computerized
McDowell, I	1989	Randomised Controlled Trial	Reminder - Administrative
McDowell, I	1989	Randomised Controlled Trial	Reminder - Administrative
McDowell, I	1990	Randomised Controlled Trial	Reminder - Administrative
McIsaac, WJ	1998	Randomised Controlled Trial	Not Computerized
McKinley, BA	2001	Randomised Controlled Trial	No Evidence Delivery
McPhee, SJ	1989	Randomised Controlled Trial	Reminder - Administrative
Millstein, SG	1983	Randomised Controlled Trial	No Evidence Delivery
Moran, ML.	1992	Randomised Controlled Trial	Teaching
Naglie, G	1993	Randomised Controlled Trial	No Evidence Delivery
Newman, MG	1997	Randomised Controlled Trial	No Evidence Delivery
Niemann, H	1990	Randomised Controlled Trial	Therapy - no evidence delivery
Ornstein, SM	1991	Randomised Controlled Trial	Not Computerized
Peck, CC	1973	Randomised Controlled Trial	Dose Calculation
Peterson, CM	1986	Randomised Controlled Trial	Dosage Delivery
Poller, L	1998	Randomised Controlled Trial	Dose Calculation
Poller, L	1992	Randomised Controlled Trial	Dose Calculation
Raynor, DK	1993	Randomised Controlled Trial	Not Patient Specific
Reid, JA	1987	Randomised Controlled Trial	Drug Administration
Reid, RA	1977	Randomised Controlled Trial	Teaching
Robertson, IH	1990	Randomised Controlled Trial	Therapy - no evidence delivery
Rodman, JH	1984	Randomised Controlled Trial	Dosage Monitoring

First Author	Year	Study Design	Reason for Exclusion
Rogers, DA	1998	Randomised Controlled Trial	Teaching
Rogers, JL	1976	Randomised Controlled Trial	Administrative
Rosser, WW	1992	Randomised Controlled Trial	Reminder - Administrative
Rosser, WW	1991	Randomised Controlled Trial	Reminder - Administrative
Ryff-de Leche, A	1992	Randomised Controlled Trial	Dose monitoring
Salim Silva, M	2002	Randomised Controlled Trial	Reminder - Administrative
Selmi, PM	1990	Randomised Controlled Trial	No Evidence Delivery
Sheiner, LB	1975	Randomised Controlled Trial	Dose Calculation
Shon, J	2000	Randomised Controlled Trial	No Evidence Delivery
Simkins, CV	1986	Randomised Controlled Trial	Reminder - Administrative
Slobounov, SM	1999	Randomised Controlled Trial	No Evidence Delivery
Stehr-Green, PA.	1993	Randomised Controlled Trial	Reminder - Administrative
Szilagyi, PG	1992	Randomised Controlled Trial	Reminder - Administrative
Thomas-Stonell, N	1994	Randomised Controlled Trial	No Evidence Delivery
Tierney, WM	1986	Randomised Controlled Trial	Not Patient Specific
Tierney, WM	1990	Randomised Controlled Trial	Reminder - Administrative
Turner, RC	1994	Randomised Controlled Trial	Reminder - Administrative
Vadher, BD	1997	Randomised Controlled Trial	Dose Calculation
Vadher, BD	1997	Randomised Controlled Trial	Dose Calculation
Walker, NM	1999	Randomised Controlled Trial	Reminder - Administrative
Weber, BE	1997	Randomised Controlled Trial	Not Computerized

First Author	Year	Study Design	Reason for Exclusion
Weinberger, M	1988	Randomised Controlled Trial	Reminder - Administrative
Weingarten, MA	1989	Randomised Controlled Trial	Not Patient Specific
Wesnes, KA	2002	Randomised Controlled Trial	Not Randomised to Intervention
Whiting-O'Keefe, QE	1985	Randomised Controlled Trial	Reminder - Administrative
Wilkinson, WE	1982	Randomised Controlled Trial	Not at Point of Care
Wilson, GA	1982	Randomised Controlled Trial	Administration
Winickoff, RN	1984	Randomised Controlled Trial	Not at Point of Care
Winzelzelburg, AJ	1998	Randomised Controlled Trial	Not Patient Specific
Wolffing, BK	1990	Randomised Controlled Trial	Not Patient Specific
Yarnall, KSH	1998	Randomised Controlled Trial	Reminder - Administrative
Antman, EM	1992	Systematic Review	Not Computerized
Austin, SM	1994	Systematic Review	Reminder - Administrative
Balas, EA	2000	Systematic Review	Not Patient Specific
Broadstock, M	2001	Systematic Review	No Evidence Delivery
Chatellier, G	1998	Systematic Review	No Evidence Delivery
Cohen, PA	1992	Systematic Review	Teaching
Eysenbach, G	2002	Systematic Review	No Evidence Delivery
Mandelblatt, J	1995	Systematic Review	Not Computerized
Oxman, AD	1995	Systematic Review	Not Computerized
Scheid; D.	2001	Systematic Review	Reminder - Administrative
Shea, S	1996	Systematic Review	Reminder - Administrative
Thomas, LH	1999	Systematic Review	Not Computerized

First Author	Year	Study Design	Reason for Exclusion
Walton, R	1999	Systematic Review	Dose Calculation
Walton, RT	2001	Systematic Review	Dose Calculation

Table 3: Characteristics of included randomised controlled trials

First Author	Year of Publication	Country	Jadad Score	Study Design	Contamination	Unit of Analysis ERROR	Number of Randomised Participants			Setting
							Total	Per Group		
								Intervention	Control	
Alterman, AI	1991	USA	1	Parallel	Yes	No	91	45	46	Inpatient
Andrewes, DG	1996	Australia	1	Parallel	Yes	No	54	27	27	Outpatient
Barry, MJ	1997	USA	2	Parallel	Yes	No	291	142	149	Outpatient
Bass, DM	1998	USA	2	Parallel	No	No	102	51	51	Home
Ben Said, M	1994	France	1	Parallel	Yes	No	158	79	79	Inpatient
Cannon, DS	2000	USA	3	Parallel	Yes	No	83	37	41	Outpatient
Casper, GR	1995	USA	1	Parallel	No	No	102	47	51	Home
Chase, CR	1983	USA	3	Parallel	Yes	No	623	272	247	Inpatient
Christakis, DA	2001	USA	3	Parallel	Yes	No	38	19	19	Outpatient
Coe, FL	1977	USA	2	Parallel	Yes	No	116	Did not state	Did not state	Outpatient
Dayton, CS	2000	USA	1	Parallel	No	Yes	29	12	17	Other
Delichatsios, HK	2001	USA	1	Parallel	No	No	298	148	150	Home
Demakis, JG	2000	USA	3	Cluster	Yes	Yes	299	146	153	Outpatient
Dexter, PR	2001	USA	2	Cluster	Yes	Yes	8	4	4	Inpatient
Edworthy, SM	1999	Canada	3	Parallel	Yes	No	256	126	126	Outpatient
Evans, RS	1994	USA	2	Cross-over	Yes	Not enough information	28	Did not state	Did not state	Inpatient
Fihn, SD	1994	USA	2	Parallel	Yes	No	620	301	319	Outpatient
Flatley Brennan, P	1995	USA	2	Parallel	No	No	102	51	51	Home
Glasgow, RE	1996	USA/UK	1	Cluster	No	No	206	108	98	Outpatient
Graham, W	2000	UK	2	Parallel	Yes	No	1050	524	526	Outpatient

First Author	Year of Publication	Country	Jadad Score	Study Design	Contamination	Unit of Analysis ERROR	Number of Randomised Participants			Setting
							Total	Per Group		
								Intervention	Control	
Gustafson, DH	1994	USA	1	Parallel	No	No	204	107	97	Home
Gustafson, DH	1998	USA	2	Parallel	No	No	219	118	101	Home
Gustafson, DH	2001	USA	2	Parallel	No	No	295	147	148	Home
Hetlevik, I	1999	Norway	2	Cluster	No	Yes	29	18	12	Outpatient
Hetlevik, I	2000	Norway	2	Cluster	No	Yes	30	18	12	Outpatient
Hobbs, FDR	1996	UK	1	Cluster	No	Yes	25	21	4	Outpatient
Horan, PP	1990	USA	2	Parallel	No	No	20	10	10	Home
Litzelman, DK	1993	USA	1	Cluster	Yes	Yes	32	16	16	Outpatient
Lobach, DF	1997	USA	1	Parallel	Yes	No	30	16	14	Outpatient
McCowan, C	2001	UK	3	Cluster	No	Yes	46	21	25	Outpatient
McDonald, CJ	1976	USA	2	Parallel	Yes	Yes	257	119	107	Outpatient
McDonald, CJ	1980	USA	2	3 treatment cross-over	Yes	No	31	Did not state	Did not state	Outpatient
McDonald, CJ	1984	USA	1	Cluster	Yes	Yes	115	61	54	Outpatient
McPhee, SJ	1991	USA	1	Parallel	No	No	40	20	20	Outpatient
Medow, MA	2001	USA	1	Parallel	No	No	56	27	29	Other
Montgomery, AA	2000	UK	3	Cluster	No	Yes	27	Intervention 1 = 10 Intervention 2 = 10	7	Outpatient
Nilasena, DS	1995	USA	1	Parallel	Yes	No	35	17	18	Outpatient
Overhage, JM	1996	USA	2	Cluster	Yes	Yes	24	12	12	Inpatient
Overhage, JM	1997	USA	1	Cluster	Yes	Yes	6	3	3	Inpatient
Petrucci, K	1992	USA	2	Cluster	No	Yes	3	Intervention 1 = 1 Intervention 2 = 1	1	Inpatient
Rhodes, KV	2001	USA	0	Parallel	Yes	No	470	248	222	Outpatient
Rogers, JL	1979	USA	2	Parallel	Yes	No	484	241	238	Outpatient
Rogers, JL	1982	USA	1	Parallel	Yes	No	484	241	238	Outpatient
Rogers, JL	1984	USA	1	Parallel	Yes	No	484	242	242	Outpatient

First Author	Year of Publication	Country	Jadad Score	Study Design	Contamination	Unit of Analysis ERROR	Number of Randomised Participants			Setting
							Total	Per Group		
								Intervention	Control	
Rossi, RA	1997	USA	2	Parallel	Yes	Yes	71	36	35	Outpatient
Rubenstein, LV	1995	USA	2	Parallel	Yes	Yes	73	40	33	Outpatient
Rubin, DH	1986	USA	3	Parallel	Yes	No	65	32	33	Outpatient
Shegog, R	2001	USA	1	Parallel	No	No	76	38	33	Outpatient
Shojania, KG	1998	USA	0	Parallel	Yes	No	396	198	198	Inpatient
Tierney, WM	1988	USA	1	Parallel	Yes	Not enough information	9496	4768	4728	Outpatient
Turnin, MG	1993	France	2	Parallel	No	No	105	54	51	Home
Vissers, MC	1996	Nether-lands	1	Cross-over	Yes	Yes	8	Did not state	Did not state	Outpatient
Wellwood, J	1992	UK	2	Cluster/ Cross-over	Yes	Yes	8	4	4	Outpatient
Wetstone, SL	1985	USA	2	Parallel	Yes	No	36	18	18	Outpatient
Wheeler, LA	1985	USA	1	Parallel	No	No	32	16	16	Home
White, KS	1984	USA	3	Parallel	Yes	No	396	211	185	Inpatient
Williams, RB	1998	USA	2	Cluster	No	Yes	60	30	30	Outpatient

Table 4: Description of Study by Goal of Intervention – Diagnosis

First Author	Year of Publication	Clinical area	Who Uses the Intervention?	Active or Passive	Primary outcome	Category of Primary Outcome (i.e. process of care, patient health or other)	Primary Outcome: Stated or Inferred	Benefit (Yes/No)*
Cannon, DS	2000	Mood Disorders	Providers	Active	Number of patients screened for mood disorder	Process	Inferred	Yes
Hetlevik, I	1999	Diabetes, Hypertension, and Hypercholestrolemia	Providers	Passive	Systolic Blood Pressure	Patient	Stated	No
Hetlevik, I	2000	Diabetes, Hypertension, and Hypercholestrolemia	Providers	Passive	Fractions of participants without registration of HbAlc	Patient	Inferred	No
Medow, MA	2001	Depression	Providers	Passive	Change in diagnostic accuracy	Other	Inferred	Yes
Wellwood, J	1992	Abdominal Pain	Providers	Passive	Diagnostic Accuracy	Other	Inferred	No

*Based on primary outcome variable

Table 5: Description of Study by Goal of Intervention – Management

First Author	Year of Publication	Clinical area	Who Uses the Intervention?	Active or Passive	Primary outcome	Category of Primary Outcome (i.e. process of care, patient health or other)	Primary Outcome: Stated or Inferred	Benefit* (Yes/No)
Alterman, AI	1991	Alcohol Abuse	Patients	Passive	Knowledge	Other	Inferred	No
Andrewes, DG	1996	Anorexia/ Bulimia	Patients	Passive	Change in knowledge	Other	Inferred	Yes
Ben Said, M	1994	Hypertension	Patients	Passive	Evolution of knowledge	Other	Stated	Yes
Chase, CR	1983	Respiratory	Providers	Active	Number of high risk patients receiving preoperative therapy	Process	Inferred	Yes
Coe, FL	1977	Hypertension	Providers	Active	Change in diastolic blood pressure	Patient	Inferred	No
Demakis, JG	2000	Ambulatory Care	Providers	Active	Percent of time user complied with recommendations	Process	Stated	Yes
Edworthy, SM	1999	Arthritis	Patients	Passive	Number of patients who used medication properly	Process	Stated	No
Fihn, SD	1994	Anticoagulation	Providers	Passive	Length of Follow-up interval	Process	Stated	Yes
Glasgow, RE	1996	Diabetes	Patients	Passive	Dietary behaviour - (score on food habits questionnaire)	Process	Stated	Yes
Graham, W	2000	Prenatal care	Patients	Passive	Number of women who underwent or booked an ultrasound	Process	Inferred	No

First Author	Year of Publication	Clinical area	Who Uses the Intervention?	Active or Passive	Primary outcome	Category of Primary Outcome (i.e. process of care, patient health or other)	Primary Outcome: Stated or Inferred	Benefit* (Yes/No)
Hobbs, FDR	1996	Hyperlipidaemia	Providers	Passive	Change in the number of referrals to a specialist	Process	Inferred	No
Horan, PP	1990	Diabetes	Patients	Passive	Average blood glucose levels before lunch	Patient	Inferred	Yes
Lobach, DF	1997	Diabetes	Providers	Active	Percent of time user complied with recommendations	Process	Stated	Yes
McCowan, C	2001	Asthma	Providers	Passive	Asthma severity (Number of patient initiated consultations with their physician)	Patient	Stated	Yes
McDonald, CJ	1976	Diabetes	Providers	Active	Percent of time user complied with recommendations	Process	Inferred	Yes
McDonald, CJ	1980	General Medicine	Providers	Active	Percent of time user complied with recommendations	Process	Inferred	Yes
Montgomery, AA	2000	Hypertension	Providers	Passive	Percent of patients in each group with 5 year cardiovascular risk of 10% or higher	Patient	Stated	No
Nilasena, DS	1995	Diabetes	Providers	Active	Change in compliance with diabetes guidelines	Process	Inferred	No
Overhage, JM	1997	General Medicine	Providers	Active	Percent of time user complied with recommendations	Process	Stated	Yes

First Author	Year of Publication	Clinical area	Who Uses the Intervention?	Active or Passive	Primary outcome	Category of Primary Outcome (i.e. process of care, patient health or other)	Primary Outcome: Stated or Inferred	Benefit* (Yes/No)
Petrucci, K	1992	Incontinence	Providers	Passive	Average number of wetting occurrences	Patient	Stated	Yes
Rogers, JL	1979	Inpatient Care	Providers	Active	Incidence of hospitalisation over two years	Patient	Inferred	No
Rogers, JL	1982	Hypertension, obesity, renal disease	Providers	Passive	Number of diets reviewed in obese patients over 2 year period	Process	Inferred	No
Rogers, JL	1984	Outpatient Care	Providers	Active	Perception of health status	Other	Inferred	Yes
Rubenstein, LV	1995	Functional status of feedback	Providers	Active	Change in functional status	Patient	Inferred	No
Rubin, DH	1986	Asthma	Patients	Passive	Change in knowledge	Other	Inferred	Yes
Shegog, R	2001	Asthma	Patients	Passive	Change in asthma knowledge	Other	Inferred	No
Turnin, MG	1993	Diabetes	Patients	Passive	Change in knowledge at 6months	Other	Inferred	Yes
Wetstone, SL	1985	Arthritis	Patients	Passive	Knowledge	Other	Inferred	Yes
Wheeler, LA	1985	Diabetes	Patients	Passive	Change in weight at 4 weeks	Patient	Inferred	Yes
White, KS	1984	Digoxin Toxicity	Providers	Active	Percent of time user complied with recommendations	Process	Inferred	Yes

* Based on primary outcome variable

Table 6: Description of Study by Goal of Intervention – Prediction

First Author	Year of Publication	Clinical area	Who Uses the Intervention?	Active or Passive	Primary outcome	Category of primary outcome (i.e. process of care, patient health or other)	Primary outcome: stated or inferred	Benefit* (Yes/No)
Tierney, WM	1988	not specified	Providers	Passive	Number and types of diagnostic tests ordered	Other	Inferred	No

* Based on primary outcome variable

Table 7: Description of Study by Goal of Intervention – Prescription

First Author	Year of Publication	Clinical area	Who Uses the Intervention?	Active or Passive	Primary outcome	Category of primary outcome (i.e. process of care, patient health or other)	Primary outcome: stated or inferred	Benefit* (Yes/No)
Christakis, DA	2001	Otitis Media	Providers	Both	Change in frequency of prescribing antibiotics for less than 10 days	Process	Stated	Yes
Evans, RS	1994	Infectious diseases	Providers	Passive	Cost per patient	Other	Inferred	Yes
Rossi, RA	1997	Hypertension	Providers	Active	Number of prescription changes	Process	Inferred	Yes
Shojania, KG	1998	Infection	Providers	Active	Number of vancomycin prescriptions	Process	Stated	Yes

* Based on primary outcome variable

Table 8: Description of Study by Goal of Intervention – Prevention

First Author	Year of Publication	Clinical area	Who Uses the Intervention?	Active or Passive	Primary outcome	Category of primary outcome (i.e. process of care, patient health or other)	Primary outcome: stated or inferred	Benefit* (Yes/No)
Dayton, CS	2000	Tuberculosis	Providers	Passive	Percent of time user complied with guidelines	Process	Inferred	Yes
Delichatsios, HK	2001	Diet	Patients	Passive	Change in global diet quality at 6 months	Process	Stated	Yes
Dexter, PR	2001	General preventive medicine	Providers	Active	Ordering rate of preventive therapy (aspirin)	Process	Stated	Yes
Litzelman, DK	1993	Cancer	Providers	Active	Percent of time user complied with recommendations	Process	Stated	Yes
McDonald, CJ	1984	General Practice	Providers	Active	Percent of time user complied with recommendations	Process	Inferred	Yes
McPhee, SJ	1991	Cancer	Providers/ patients	Active	Average number of patients assessed for smoking	Process	Inferred	Yes
Overhage, JM	1996	Inpatient Care	Providers	Active	Percent of time user complied with recommendations	Process	Stated	No
Rhodes, KV	2001	Risky Behaviors	Patients	Passive	Number of patients reported receiving advice on how to improve their health	Process	Inferred	Yes
Williams, RB	1998	Cancer	Providers/ patients	Passive	Change in percent of patients undergoing screening tests	Process	Stated	No

* Based on primary outcome variable

Table 9: Description of Study by Goal of Intervention - Support

First Author	Year of Publication	Clinical area	Who Uses the Intervention?	Active or Passive	Primary outcome	Category of primary outcome (i.e. process of care, patient health or other)	Primary outcome: stated or inferred	Benefit* (Yes/No)
Bass, DM	1998	Caregiver Strain	Caregivers	Passive	Caregiver strain defined by activity restriction	Other	Stated	No
Casper, GR	1995	Alzheimer's disease	Caregivers	Passive	Average change in decision making confidence	Other	Stated	Yes
Flatley Brennan, P	1995	Alzheimer's disease	Caregivers	Passive	Change in decision making confidence	Other	Stated	Yes
Gustafson, DH	1998	AIDS/ HIV	Patients	Passive	Quality of life (depression score)	Other	Inferred	No
Gustafson, DH	1994	AIDS/ HIV	Patients	Passive	Average quality of life score	Other	Inferred	Yes
Gustafson, DH	2001	Breast Cancer	Patients	Passive	Quality of life	Other	Inferred	Yes

* Based on primary outcome variable

Table 10: Description of Study by Goal of Intervention - Treatment

First Author	Year of Publication	Clinical area	Who Uses the Intervention?	Active or Passive	Primary outcome	Category of primary outcome (i.e. process of care, patient health or other)	Outcome Stated/ Inferred	Benefit* (Yes/No)
Barry, MJ	1997	Hyperplasia	Patients	Passive	Number of patients who decided to have a prostatectomy	Process	Inferred	No
Vissers, MC	1996	Trauma	Providers	Passive	Percent of times treatment matched recommendation	Process	Inferred	No

* Based on primary outcome variable

Table 11: Characteristics of included systematic reviews

First Author	Year	Oxman and Guyatt score (1-7)	Number of Included studies	Goals of interventions reviewed	User of interventions	Overall findings
Balas, E.A.	1996	2	98	Dosage Diagnosis Management Treatment Prevention	Providers Patients	Enhanced physician performance and patient health outcomes
Balas, E.A.	1998	2	15	Management	Patients	Improved patient health outcomes
Buntinx, F	1993	2	26	Prevention Diagnosis	Physicians	Adherence to guidelines was improved
Colombet, I	1999	1	11	Prediction Diagnosis	Physicians	Physician Process of care Patient outcome
Hunt, D.L.	1998	7	68	Dosage Prevention Diagnosis Other	Physicians	Physician performance enhanced for dosing, preventive care, other medical care No change in patient health outcomes
Krishna, S	1997	2	22	Management Prevention	Patients	Improved patient health outcomes, knowledge, and behaviour
Montgomer, A.A	1998	4	7	Management	Physicians	Enhanced physician performance Not patient health outcomes
Revere, D	2000	4	37	Management Prevention	Patients	Improve patient health behaviours
Shiffman, R.N.	1998	2	25	Management Treatment Prevention Prescription	Physicians	Adherence to guidelines can be improved

Sullivan, F	1995	2	30	Prevention Prescription Consultation	Physicians	Physician process of care

Figure 1: Flow through the stages of study inclusion/exclusion

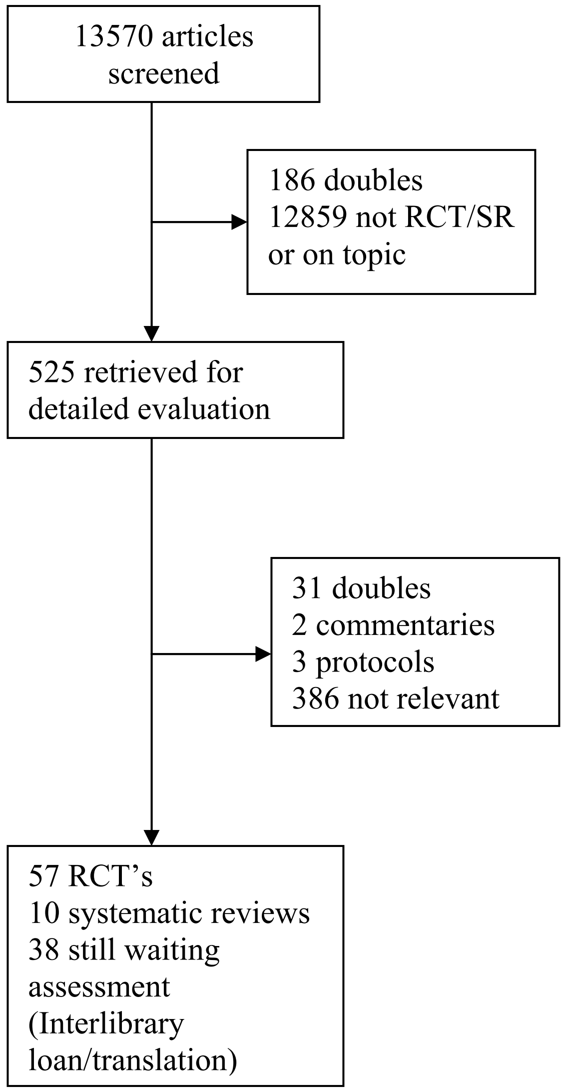


Figure 2: Meta-graph, process of care

Study	Year	User	Type	SMD (95% CI)
Diagnosis				
Cannon	2000	Provider	Active	0.78(0.15,1.4)
Management				
Rogers	1982	Provider	Passive	0.38(-0.03,0.79)
McDonald	1976	Provider	Active	0.85(0.64,1.05)
Rogers	1979	Provider	Active	1.97(1.54,2.4)
McDonald	1980	Provider	Active	0.86(0.34,1.38)
Chase	1983	Provider	Active	1.07(0.59,1.55)
White	1984	Provider	Active	0.28(0.08,0.48)
Demakis	2000	Provider	Active	0.12(0.1,0.14)
Rubin	1986	Patient	Passive	0.68(0.13,1.23)
Turnin	1993	Patient	Passive	0.34(-0.08,0.76)
Glasgow	1996	Patient	Passive	0.39(0.09,0.69)
Edworthy	1999	Patient	Passive	0.27(-0.07,0.61)
Graham	2000	Patient	Passive	-0.01(-0.21,0.2)
Montgomery	2000	Provider/ Patient	Passive	0.03(-0.21,0.28)
Diagnosis/ Management				
Hetlevik	2000	Provider	Passive	0.05(-0.14,0.25)
Prescription				
Rossi	1997	Provider	Active	2.13(1.03,3.22)
Shojania	1998	Provider	Active	0.23(0.03,0.43)
Christakis	2001	Provider	Passive/ Active	1.77(0.87,2.67)
Prevention				
Overhage	1996	Provider	Passive	0.57(-1.18,2.32)
Dayton	2000	Provider	Passive	1.58(1,2.16)
Litzelman	1993	Provider	Active	0.46(0.16,0.76)
Dexter	2001	Provider	Active	0.23(0.13,0.32)
Delichatsios	2001	Patient	Passive	0.73(0.35,1.11)
Rhodes	2001	Patient	Passive	0.82(0.58,1.05)
McDonald	1984	Provider/ Patient	Active	0.48(0.11,0.86)
McPhee	1991	Provider/ Patient	Active	0.8(0.15,1.46)
Support				
Gustafson	1998	Patient	Passive	-0.13(-0.42,0.16)
Treatment				
Vissers	1996	Provider	Passive	0.12(-0.17,0.42)
Barry	1997	Patient	Passive	0.18(-0.46,0.81)
Overall	Fixed Effects			0.14(0.13,0.16)
Overall	Adj. Random Effects			0.16(0.03,0.3)

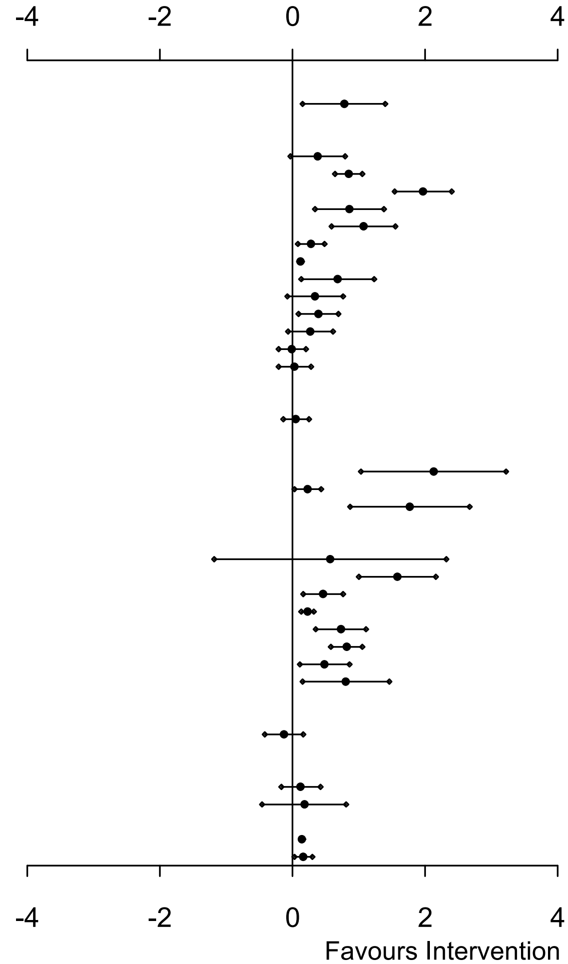


Figure 3: Funnel plot, process of care outcome

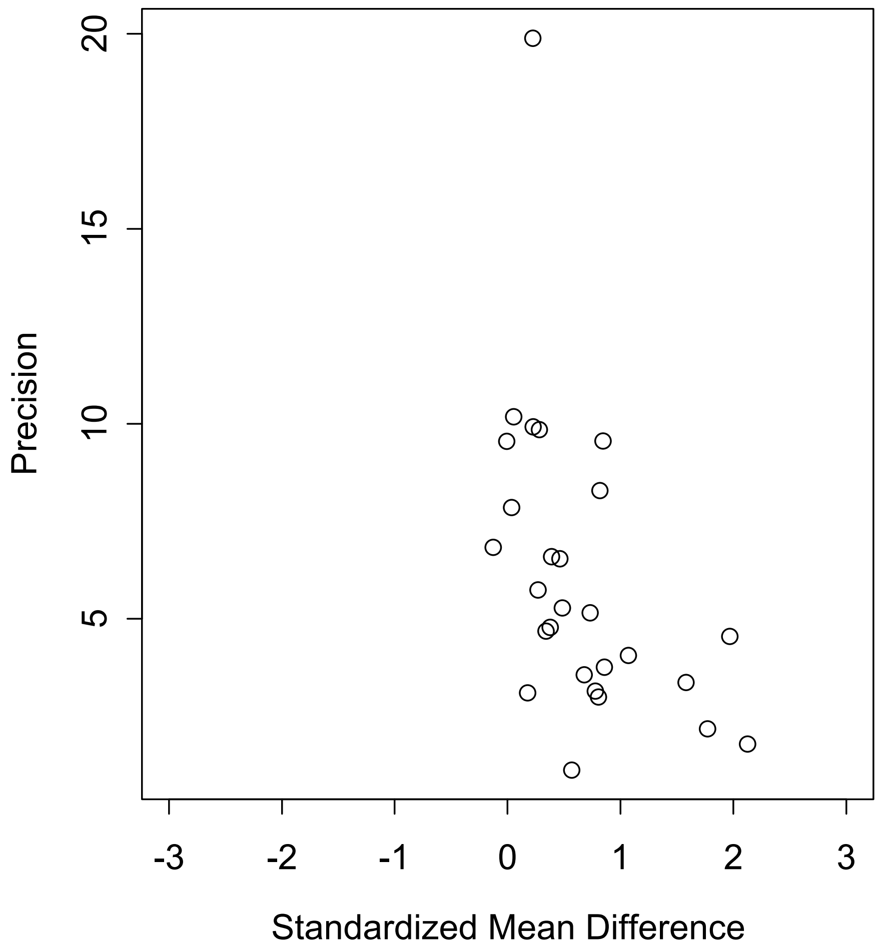


Figure 4: Meta-graph, patient health outcome

Study	Year	User	Type	SMD (95% CI)
Management				
Rogers	1982	Provider	Passive	0.04(-0.22,0.29)
Fihn	1994	Provider	Passive	0.08(-0.08,0.24)
Coe	1977	Provider	Active	-0.1(-0.47,0.26)
Rogers	1979	Provider	Active	0.06(-0.15,0.27)
Rubenstein	1995	Provider	Active	-0.29(-0.5,-0.07)
Wheeler	1985	Patient	Passive	-0.43(-1.2,0.34)
Edworthy	1999	Patient	Passive	-0.19(-0.58,0.19)
Montgomery	2000	Provider/ Patient	Passive	-0.05(-0.42,0.33)
McCowan	2001	Provider/ Patient	Passive	-0.29(-0.53,-0.04)
Diagnosis/ Management				
Hetlevik	1999	Provider	Passive	0.06(-0.03,0.15)
Hetlevik	2000	Provider	Passive	-0.06(-0.21,0.09)
Prevention				
Delichatsios	2001	Patient	Passive	-0.16(-0.53,0.22)
Overall	Fixed Effects			-0.02(-0.08,0.04)

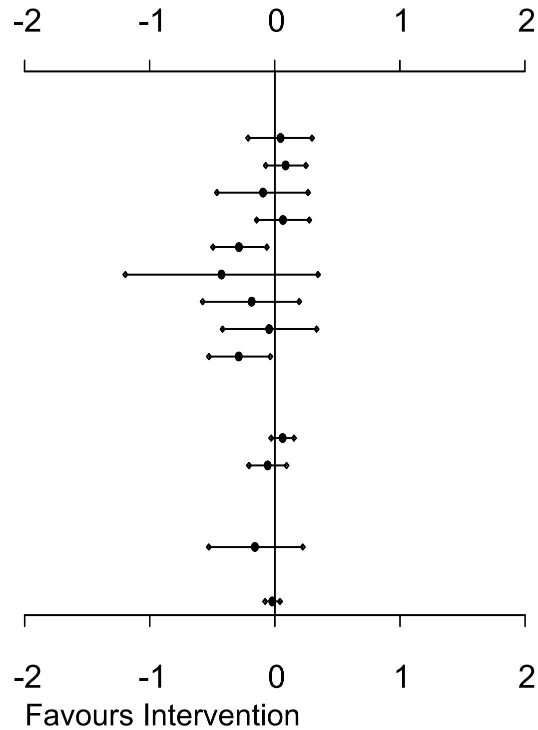


Figure 5: Funnel Plot, patient health outcome

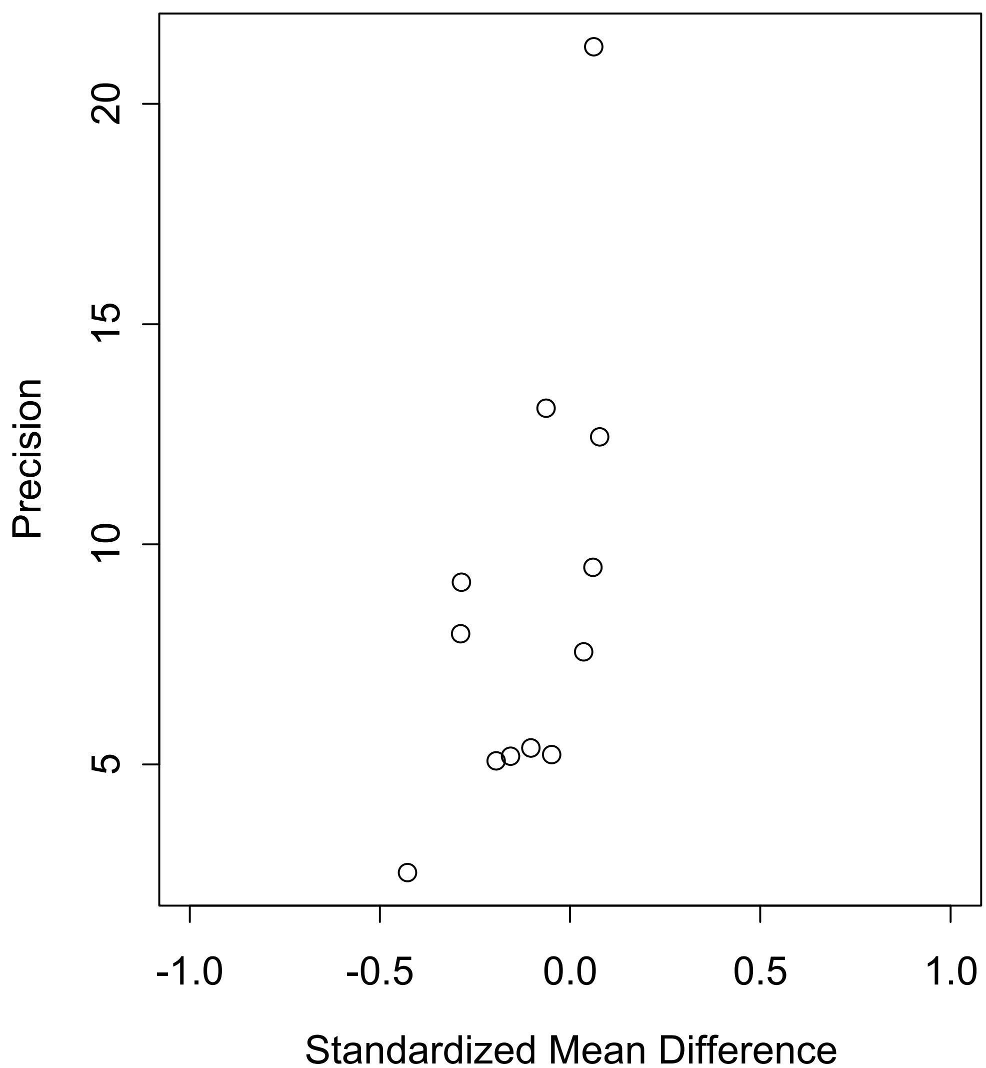


Figure 6: Meta-graph, Knowledge

Study	Year	User	Type	SMD (95% CI)
Management				
Wheeler	1985	Patient	Passive	1.27(0.51,2.04)
Rubin	1986	Patient	Passive	0.93(0.37,1.5)
Horan	1990	Patient	Passive	0.22(-0.75,1.2)
Alterman	1991	Patient	Passive	0.32(-0.09,0.74)
Turnin	1993	Patient	Passive	0.88(0.46,1.3)
Said	1994	Patient	Passive	0.41(0.07,0.75)
Wetstone	1995	Patient	Passive	1.47(0.71,2.22)
Andrewes	1996	Patient	Passive	0.87(0.31,1.43)
Graham	2000	Patient	Passive	-0.09(-0.49,0.31)
Shegog	2001	Patient	Passive	0.07(-0.4,0.54)
Overall	Fixed Effects			0.5(0.34,0.65)
Overall	Adj. Random Effects			0.44(0.13,0.75)

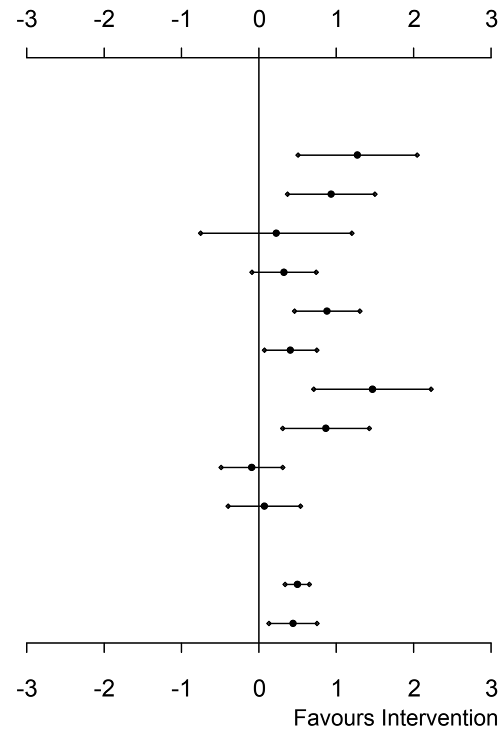
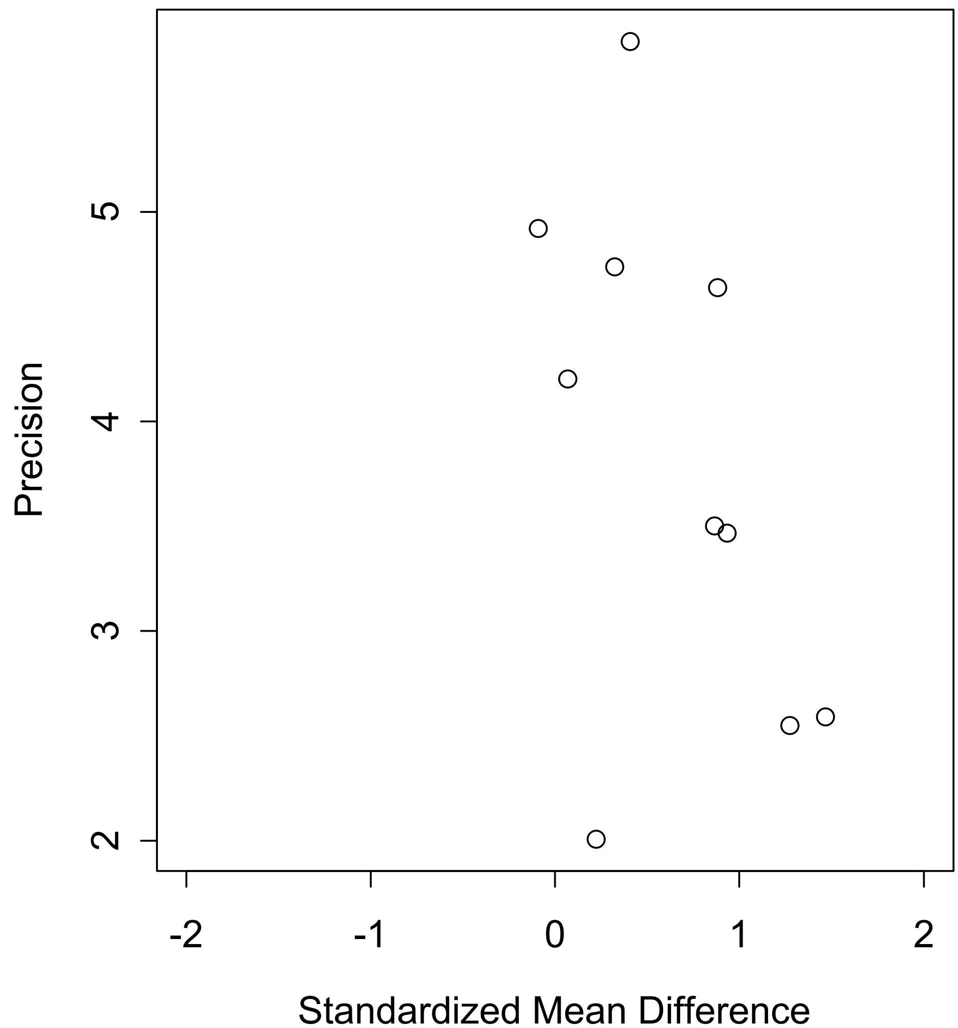


Figure 7: Funnel Plot, Knowledge



Final Report
Part II

Computer-Based Delivery of Health Evidence: Engaging Key Stakeholders and Policy Makers

Final Report For
The Alberta Heritage Foundation
for Medical Research

January 2003

Final Report to the
Alberta Heritage Foundation for Medical Research

Computer-Based Delivery of Health Evidence: Engaging Key Stakeholders and Policy Makers

January 2003

Partners:
The Alberta Research Centre for Child Health Evidence, Department of Paediatrics, University of Alberta
Centre for Community Child Health Research, University of British Columbia

Authors:
Lisa Hartling, Kristie Cramer, Natasha Wiebe, Kelly Russell, Ellen Crumley, Dr. Martin Pusic, Dr. Terry P. Klassen.

For further information please contact:

Kristie Cramer
Project Coordinator
Alberta Research Centre for Child Health Evidence
9428 Aberhart Centre One
11402 University Avenue
Edmonton, Alberta
T6G 2J3
Phone: 780.492.6184
Fax: 780.407.6435
Email: **kcramer@ualberta.ca**

Summary

The Alberta Research Centre for Child Health Evidence (ARCHE) along with a medical informatics specialist from the Centre for Community Child Health Research reviewed the "State of the Science" around information management systems. Specifically, they addressed whether computer-based evidence delivery systems enhance the process of care and/or patient health outcomes. As part of this review, the research team recruited various stakeholders and policy makers with an interest and understanding of these systems. The reason for engaging these stakeholders and policy makers was to place the findings of the review within the context of what is currently known, to summarize the strengths and weakness in the research base, to identify gaps in knowledge and to disseminate the findings so they will have the greatest impact on stakeholders and policy makers.

Many questions emerged through our engagement of stakeholders and policy makers. The questions of interest varied according to the different perspectives. For instance, providers want to know how these systems will affect their practice whereas administrators question how the systems will increase the efficiency of care within the system. With respect to dissemination, a key theme that emerged was the importance of identifying and engaging policy/decision-makers from the outset, particularly during the stages of topic nomination and refinement and development of the proposal. They warned about the external validity, or generalizability, of the research conducted to date. Each system needs to be assessed in the environment where it will ultimately be implemented. Finally, there was unanimous agreement among the stakeholders and policy makers that future research needs to focus on identifying the barriers to the uptake and use of these systems. Once the barriers are overcome the value of computer-based delivery of health evidence can be investigated further.

Table of Contents

Introduction

Over the past decade, policy and decision makers have been expected to consider formal "research evidence" when making decisions. Despite this emphasis on evidence-based decision-making, policy makers and researchers generally have difficulty connecting in a timely fashion. Researchers may take years to complete a study with the final product, usually a publication, arriving in a format or at a time that is unhelpful to the policy maker. It is doubtful that any relevant research products will be available to policy makers without prior collaboration to match the agendas and priorities of the policy maker and the researcher. Thus, there is a gap between the research findings and the decisions of policy makers[1].

> There is a need, then, to optimize the use of research information in health care policy and decision-making. There is also a need to incorporate the health policy agenda into research questions. Creating collaborative relationships between policy makers and researchers is the first step to bridging the gap between them. Early and ongoing collaboration between researchers and policy makers ensures that relevant questions are being asked and the research evidence will be used[2]. The exchange, synthesis and application of knowledge (i.e. knowledge translation) within a complex system of relationships among researchers and users (e.g. policy makers, program planners, providers etc.) is an integral part of the research process[3]. The success of transforming research findings into beneficial actions is dependent upon maintaining a continual exchange of information between researchers and the potential users of the research findings.

There are innumerable areas within the health care field where bridging the gap between researchers and policy makers would prove to be valuable. In a general effort to ensure that policy makers value health research, and thereby support evidence based decision making in health, the Alberta Heritage Foundation For Medical Research, Alberta Health and Wellness, and Listening for Directions identified key areas and associated research questions that are a priority in health services and health policy research. Researchers were asked to review the "State of the Science" in one of these key areas by summarizing the literature and working with key stakeholders to identify the gaps in knowledge. The aim of these reviews is to inform future health planning and research activity, to set the stage for the development of programs of research, to identify and address gaps in knowledge, and to answer priority research questions. The end goal is to identify areas where long-term health research programs would provide the most value in informing health policy and decision-making.

> The Alberta Research Centre for Child Health Evidence (ARCHE) along with a medical informatics specialist from the Centre for Community Child Health Research reviewed the "State of the Science" around information management systems. Specifically, they addressed whether computer-based delivery of evidence systems enhance the process of care and/or patient health outcomes. As part of this review, the research team recruited various stakeholders and policy makers with an interest and understanding of these systems. The reason for engaging these stakeholders and policy makers was to place the findings of the review within the context of what is currently known, to summarize the strengths and weakness in the research base, to identify gaps in knowledge and to disseminate the findings so they will have the greatest impact on stakeholders and policy makers. This report summarizes the results of engaging these key stakeholders and policy makers.

Advisory Committee

Key national and provincial stakeholders (Appendix A) who have an interest in medical informatics were identified and approached to be part of an advisory committee. These individuals were selected to represent different perspectives within the health care system and include: health care professionals (clinicians, nurses, pharmacists, etc.), health care decision and policy makers, and health care consumers (public, patients) throughout Alberta and Canada. Initially, the stakeholders were contacted by telephone and informed of the "State of the Science" review, its purpose and objectives, and our interest in forming an advisory committee. In addition, a written description of the purpose of the review and the advisory committee's responsibilities was emailed to each stakeholder (Appendix B). Ten of the fourteen stakeholders, who were approached, agreed to sit on the advisory committee and took part in an advisory committee conference call. The purpose of this conference call was to introduce the committee members and research team, explain the project in more detail, and address any questions or concerns. Following the conference call, the minutes of the meeting along with the research team's responses to any concerns were emailed to each committee member (Appendix C). Any issues that were raised or unclear during the conference call were addressed in the minutes. Next, semi-structured personal interviews were scheduled with each committee member (Appendix D). These interviews were conducted in person or over the telephone at the committee member's convenience.

Advisory Committee's Input

The conference calls and one-on-one meetings proved to be very informative. The current state of the knowledge, gaps in the knowledge, strengths and weaknesses of the literature, and methods for dissemination of new research around computer-based health evidence delivery systems were discussed. Often the discussions and comments moved outside of our review and addressed the broader scope of medical informatics research. What follows is a summary of those meetings:

Impressions of computer-based health evidence delivery systems:

- These systems are functional. The technology works.
- Systems that help with forgetfulness are the most effective.
- Feedback systems increase the use of the evidence provided.
- The less time there is between the use of these systems and the patient visit the more likely the health care provider will apply the information provided (less time to forget information)
- Following implementation of these systems there is a high volume of use followed by a drop-off and levelling out of use. This occurs as users discover what the systems are useful for and what they are not.

The gaps in the knowledge base:

There was unanimous agreement among the committee members that the most important gap in the literature on computer-based delivery of health evidence relates to the barriers of use. What are the barriers to using these systems? In the case where they are inappropriate, how do we remove the barriers? How do we make these systems easier to use? What are the best implementation strategies for introducing these systems?

The following were also identified as areas and/or research questions that need to be investigated:

- Who do these systems work for (clinicians, nurses, patients etc.)?
- What types of systems work best (e.g., active versus passive systems, reminder systems versus feedback systems; patient versus provider systems; management versus prevention systems)?
- Are these systems performing? Do they crash, are they usable?
- Who is responsible for training the users on how to use these systems? How long does it take to train them?
- Legal issues – who is responsible for ensuring the systems are up to date and provide the best evidence? Who is liable?
- Do these systems work in the real world?
- What constitutes uptake and use?
- Over the long-term what kind of benefits do these systems have?
- Can these systems be used as education tools?
- Do they work for health care consumers? Do consumers use them? What is the quality of the evidence presented to the consumers

Criticisms of the Existing Literature/Research:
Weaknesses:

- Methodological designs do not match questions being investigated
- Research is limited to randomized controlled trials. Research focuses on effectiveness, not uptake and barriers to use.
- Studies do not assess the effect of these systems on patient health outcomes.

- Evidence from the current research cannot be generalized; the results are specific to the environment it was tested in. Each system needs to be assessed in the environment where it will ultimately be implemented.
- The use of these systems has not been evaluated when coupled with clinical events.
- Abundance of research on these systems; however there is immense variability among the types of systems and the outcome variables assessed.
- These systems are frequently designed by information technology specialists; need the input of medical professionals.
- Systems have very shallow decision trees; they only provide a limited amount of support.

Strengths:

- There are a lot of systematic reviews out there on effectiveness; a lot of replication.
- The randomized controlled trials studies have dealt with issues of contamination by using cluster designs.
- Awareness of the gaps exists in the literature.
- Recognition of the need to design systems to be used at the point of care.
- Newer systems are being designed with the input of health care professionals.

Dissemination and Implementation:

- Design systems with their potential users and maintain their support.
- Engage policy and decision makers as well as the users of these systems during the entire research process. Involve them in the question development, developing

the study design, data collection, dissemination of the findings, and implementation.

- Educate policy makers on the value of the research so they ask the right questions
- Present the findings through the users. Find a "champion" to influence their peers and promote the findings. The more people asking for these systems the more likely they will be implemented.
- Increase awareness of these systems. Distribute bulletins and newsletters to potential users and others who will benefit from these systems.
- Place in the context of individual's agenda you want to influence.
- Present information to any party who may have an interest or be influenced by these systems. The more people who know about them the better.
- Provide evidence that these systems:
    - Are used and are wanted and not abandoned
    - Create a positive change in the organization
    - Increase job satisfaction
    - Improve patient care (decrease medical errors); quality of life
    - Financial benefit (direct or indirect)
    - Are multidisciplinary and can be used in a number of settings
    - Decrease unnecessary work
    - Excellent teaching tools
- Use in medical schools, nursing schools, etc they will use them for life; find ways that focus on teaching the younger professionals as you will have more success;

Discussion

Gaps in the Knowledge Base

There are many questions in the area of computer-based methods to deliver health evidence. The questions of interest vary according to different perspectives. For instance, providers want to know how these systems will affect their practice, how much time will be required for use and training, how the systems will enhance their current knowledge, or how they will impact on the care of their patients. Professional organizations are interested in how the systems will enhance the quality and efficiency of care, how the systems are developed and the quality of information they contain, and legal issues surrounding their use. Administrators question how the systems will increase the efficiency of care within the system, how much they will cost, their cost-benefit and cost-effectiveness, how they can be implemented, and how their use can be maximized.

The different types of questions can be effectively illustrated using the technology assessment iterative loop described by Bennett and Tugwell[4]. Two questions that need to be answered early on with any new technology are the efficacy (i.e., therapeutic potential in ideal circumstances) and effectiveness (i.e., estimate of reduction of burden of illness when technology is provided in realistic service setting). Once efficacy is established then other pragmatic questions require research such as: screening and diagnosis (i.e., accurate identification of populations that will benefit most from the technology), efficiency (i.e., the relationships between costs and effects), synthesis and implementation (i.e., recommendations about diffusion and utilization of the technology), and monitoring and reassessment (i.e., selection and application of indicators of success and reassessment of burden of illness).

The study designs required to most effectively answer these questions vary. For instance, randomized controlled trials are recognized as the most appropriate design with which to address questions of efficacy[5]. Whereas, research that identifies barriers to the use of new technologies may be best answered with observational designs including studies involving survey work.

Of interest was the perception among some members of the advisory committee that computer-based health evidence delivery systems are functional and work despite the conflicting evidence in the literature. These perceptions may be based on information related to specific systems or from personal experience with the systems.

The scope of the field of medical informatics is vast. Our systematic review was limited to studies of computer-based systems that deliver some form of evidence. We excluded systems that produce printed outputs/reminders to be mailed to patients; systems that telephone patients; systems that calculate/administer drug dosages; or systems that store medical records. These systems are transaction processing or administrative systems not evidence delivery systems since they only perform administrative tasks and do not transform, integrate or deliver evidence[6]. Some members of the Advisory Committee were interested in the efficacy and effectiveness of these systems. For instance, some of the clinicians were not interested in systems that provided evidence or knowledge; this they see as the role of other continuing education activities. They were more interested in administrative systems that would increase efficiencies within their practices.

Dissemination

In terms of disseminating research findings, a key theme that emerged was the importance of identifying and engaging policy/decision-makers from the outset, particularly during the stages of topic nomination and refinement and development of the proposal. This was a weakness of our systematic review process, in that due to the project timeline, policy/decision-makers were not identified and engaged until the proposal had been written and the project was underway.

Ideally, individuals who select topics should partner with the researchers and both groups need to agree on clearly delineated roles. In the context of a systematic review, the role of policy/decision-makers should largely be to provide input on the scope of the review, to provide a context to interpret the findings, and to identify methods to disseminate the results. Policy/decision-makers should not provide input or direction around the methodology as this can introduce bias into the review process. The role of the researchers is to objectively review and synthesize the evidence that most effectively answers the objectives and to educate the policy/decision-makers about the methodological process.

Within the context of "policy/decision-makers", there are different levels and interests. For instance, hospital CEO's and presidents of professional organizations will have different questions and require different information than individual providers or clients. Each of the groups can ultimately contribute to the decision-making process but will do so in different ways. CEO's and presidents will do so from a top-down approach, whereas individual providers and clients will operate at more of a grassroots or advocacy level. The target audience will affect the presentation format of the findings and the dissemination activities.

Dissemination activities can be guided by a "Hierarchy of Research Impact" (personal communication, Dr. Carolyn Clancy, Acting Director, Agency for Healthcare Research and Quality). Within this hierarchy are four levels at which research can have an impact: Level 1: improves other research; Level 2: improves processes and policies;

Level 3: improves delivery and practice; Level 4: improves access, outcomes, efficiency. As a result of the large amount of research still required in this area, our dissemination strategies will focus on improving other research by informing medical informatics researchers of the state of science with respect to these systems. They will be encouraged to collaborate with policy/decision-makers, health care providers and system developers when undertaking further investigations of these systems. In addition, the findings of the systematic review can inform researchers regarding specific designs and methodological issues to be considered in subsequent studies.

Interpretation of Research Findings

Members of the Advisory Committee identified a number of issues that need to be addressed when interpreting research findings. Members spoke about a “honeymoon” period referring to a high volume of use immediately after the implementation of these systems, followed by a drop-off and levelling out of use. Study findings need to be interpreted in light of this in that most are of short-term duration, therefore they may overestimate the use and therefore the effects of these systems. Long-term studies would need to be conducted to evaluate the use of these systems over time. Concomitant with this is the lack of evidence about long-term benefits of these systems. Many of the studies focused on short-term, or intermediate, outcomes. For instance, outcomes focussed on the process of care or short-term improvements in patients’ signs and symptoms rather than longer-term outcomes such as morbidity and mortality. In addition, none of the studies examined or were designed to address potential adverse effects that could arise from the use (or misuse) of these systems.

The Advisory Committee warned about the external validity, or generalizability, of the research conducted to date. Evidence from the current research cannot be generalized; the results are specific to the environment in which it was tested. Each system needs to be assessed in the environment where it will ultimately be implemented.

Next Steps

In terms of future research, there was unanimous agreement among the Advisory Committee that the next step should focus on barriers to the uptake and use of these systems. For example, identifying the barriers to using these systems, mechanisms of overcoming these barriers or making the systems easier to use, and identifying effective implementation strategies. Barriers to the use of these systems need to be identified and, where these barriers are inappropriate, overcome for these systems to be of use in practice. Once the barriers are overcome the value of computer-based delivery of health evidence can be investigated further.

References

1. Lomas J. Improving Research Dissemination and Uptake in the health sector: Beyond the sound of one hand clapping. Health Policy Commentary Series 1997.

2. Lomas J. Connection Reserach and Policy . Canadian Journal of Policy Research 2000; 1(1):140-4.

3. Canadian Institute of Health Research. Knowledge Translateion Framework [Web Page]. 2002; Available at http://www.cihr-irsc.gc.ca/about_cihr/organization/knowledge_translation/kt_framework_prelim_e.shtml. (Accessed 2002).

4. Bennett KJ, Tugwell P. iterative loop gives framework for assessing technology. Dimensions in Health Service 1986; 63:68-71.

5. Sackett D. Evidence Based Medicine. Spine 1998; 23:1085-6.

6. Braden B, Corritore C, McNees P. Computerized Decision Support Systems: Implications for Practice. Nursing Informatics 1997; 46:300-4.

Appendix A: Stakeholders

Deborah Wilson:	Program Director, Clinical Practice Guidelines Department, Alberta Medical Association
Elaine Stakiw:	Director of Research and Evidence, Alberta Health and Wellness
Paul Childs:	Health Economist, Alberta Health and Wellness
Don Philippon:	Executive Director and Vice Chair, Health Sciences Council, University of Alberta
Elaine Orrbine:	Chief Executive Officer, Canadian Association of Pediatric Health Centers
Sharon Richardson:	President, Alberta Association of Registered Nurses
Robert Hayward:	Director, Centres for Health Evidence
Micheal Bullard:	Physician, Division of Emergency Medicine, University of Alberta Hospital
Donna Strating:	Vice President Informatics, Capital Health
June McGreggor:	Chief Operating Officer, WELLNET

Appendix B: Stakeholder Invite and Study Description

Computer-based Delivery of Health Evidence: A systematic Review of the Impact on Clinical Practice and Patient Outcomes

Over the past decade, health care professionals have been encouraged to apply evidence-based methods to their decision-making in clinical practice. There are numerous computer-based resources that can provide physicians with ready access to current research practice guidelines and decision-making tools. In addition, health care consumers are able to easily access health related information through sources such as the World Wide Web. They are becoming more knowledgeable regarding their medical conditions and treatments and are playing a greater role in the clinical decision-making process. Bringing relevant information to the provider and consumer at the point of care has the potential to affect practice patterns, enhance or alter decisions being made, increase efficiency in practice, and improve health outcomes for patients. These evidence delivery systems need to be rigorously evaluated before they are accepted and widely used. Evaluations of whether or to what extent these systems are having an impact are needed to discern which, if any, systems are most effective. Accordingly, our research team, the Alberta Research Centre for Child Health Evidence (ARCHE) has been funded by the Alberta Heritage Foundation for Medical Research (AHFMR) to identify and synthesize evaluations of computer-based delivery of health evidence on clinical decision-making and health outcomes.

This project is one of several projects funded by AHFMR's State of the Science review program. The State of the Science review program is part of a general effort by AHFMR to ensure that health research is valued by policy and decision makers and thereby supports evidence-based decision-making in health. Our objective is to obtain and present relevant information in a context that is useful to policy makers for guiding policy decisions and the provision of scarce resources. To do this we would like to involve decision makers and stake holders as part of an advisory committee. The advisory committee's role would be to assist us by providing direction and feedback at different stages throughout the research process. Committee members will be asked to take part in two separate conference calls scheduled at different stages during the research process. The time period in which we are to complete this project is relatively short and thus the two conference calls will be held this summer. The first call will be held at the end of June or beginning of July and the second will be held in the middle of August. The purpose of the first call is to provide a description of our study and the review process and to address any questions or concerns the committee may have. Prior to the second conference call, a draft of our review will be sent to each of the committee members. The second conference call will be held to discuss any comments or concerns the committee may have with this draft. If members are unable to attend a conference call, they will be asked to provide a list of their comments or concerns so that they can be addressed with the rest of the committee during the conference call.

If you would like to be a member of our committee, please accept our invitation by responding to Kris Cramer via email (kcramer@ualberta.ca). In addition, a list of potential meeting times for our first conference call has been included below; please inform Kris of the times that you are available and she will schedule the meeting promptly. Thank you for your time. I am looking forward to our first committee meeting.

Potential meeting times:

Advisory Committee Conference Call #1

DATE	TIME
June 25th	10am-11am
June 27th	2pm – 3pm
June 28th	10:30am – 11:30am 3pm – 4pm
July 9th	8am-9am 11am-12am

Sincerely,

Kris Cramer,
Project Coordinator

Appendix C: Minutes from Stakeholder Conference Call

On behalf of the Alberta Research Centre for Child Health Evidence (ARCHE), I would like to thank you for contributing to our consultation process. We found the meeting to be useful, enlightening and productive. You raised some very important questions and concerns during the meeting, which we have addressed below along with an overview of our next steps.

1. What is the scope of the project?

   We have been funded by AHFMR to conduct a systematic review around the effectiveness of computer-based interventions that deliver health evidence. We were granted one of five awards under the "State of the Science Reviews" program, that is a new initiative on the part of AHFMR, in collaboration with Alberta Health and Wellness. The goal of the program is to develop long-term programs of health research to inform policy and decision-making, and to contribute to developing further capacity for health services in Alberta and identify potential gaps in the research.

   In addition to the systematic review, we have been asked by AHFMR to engage key stakeholders in the area of informatics (including policy and decision-makers) to provide a context for our review, assist in the dissemination of our research findings, and offer direction for future funding programs. Doug Wilson, consultant to AHFMR, assisted us in identifying potential individuals for this process.

2. What is the research question?

   The question AHFMR has funded us to answer is: "Does the use of computer-based delivery of health evidence by health care professionals and consumers have an effect on clinical decision-making and/or patient outcomes?"

   > Computer-based delivery of health evidence is defined as: any computer software system that employs a knowledge base designed for use by a health care worker or consumer as a direct aid to clinical decision-making and/or health promotion. This excludes any system that solely fulfills an administrative roll (e.g. system that sends vaccination reminders) or whose only function is to carry out calculations (e.g. dosage calculation program).

3. What is the project timeline?

   The period of funding is from April 1 to October 31, 2002. By September 1 we must provide a progress report that includes either a draft of the policy piece or a draft of the literature review summary. A draft of the complete review is due October 1 and the final document with reviewers' comments incorporated is due October 31.

Because of this tight timeframe we have progressed with refining our question and beginning the many steps involved in a systematic review. We refined our question and methods based on what we set out to do in our original proposal and in consultation with AHFMR.

4. Who are we targeting for our Policy/Decision Maker Consultants?

   We want to target policy/decision makers or individuals who interact with or want to influence policy/decision makers in the area of informatics. We would like to engage individuals from different levels and backgrounds to provide various perspectives within the area of informatics.

5. What is the role of the Policy/Decision Maker Consultants?

   Our vision is that these consultants will give input into the "policy piece" that will provide a broader context in which to interpret our research findings. Having synthesized the literature regarding the effectiveness of computer-based interventions that deliver health evidence, we (and AHFMR) would like to know what are other questions that need to be answered and what the best approach is to filling these gaps. In addition, we would seek advice from the Consultants on how best to present and disseminate our findings so that they will be distributed to and used by the most appropriate people.

6. How will the Consultants be involved?

   It was suggested during the meeting that we hold small focus groups or interview people individually. In view of the time limitations and difficulties of scheduling group meetings, we have decided to contact Consultants individually to discuss some key issues.

7. It was felt that by limiting our review to randomized controlled trials (RCT) and systematic reviews we would overlook many important findings and would not be able to answer key questions in this area.

   The process of answering research questions is an iterative one, where different research methods are employed at different times depending on the nature of the question. Qualitative, experimental and observational research all make equally important contributions to clarifying research issues. Qualitative research is critical to formulating research questions and uncovering why a particular intervention was not effective. Randomized controlled trials provide the highest quality of evidence when investigating the effectiveness of an intervention.

   Due to the vast amount of literature on the topic we are investigating and the limited time in which we have to complete this project, we chose to limit our review to the level of evidence that is best able to answer our research question.

Given that our research question is one of effectiveness, we decided to focus on RCT's and systematic reviews. Presently, we have identified over 50 relevant RCT's and over 10 relevant systematic reviews. Some of these reviews include non-RCT's, which will help us to capture some of the evidence from qualitative and observational studies.

8. Policy/decision makers want to be informed of the barriers to the use of computer-based systems and how to avoid them.

   This is a topic where designs other than RCT's may provide more relevant information. We are aware that this is an important question to policy/decision makers and will address this issue in our policy piece.

9. The research question is too broad. Is it feasible to answer?

   There are many questions that need to be answered in the area of informatics. We are attempting to answer a focused question with respect to the effectiveness of computer-based interventions as this complements our methodological expertise and is a first step in an iterative research loop. The next steps in this loop may involve evaluating provider and patient compliance, the extent to which the resources are being used by those who could benefit, the impact of these resources in terms of efficiency within the health care system, how best to implement these resources and increase uptake, and finally, monitoring changes in population health following their implementation.

   We feel that it is feasible to answer our question within the given timeframe. However, we recognize that this represents only one small piece within the informatics field. It is therefore important that we place our findings in a broader context to guide future research that will be of use to decision makers. This is where we are asking for your input.

I hope I have clarified some of your questions and concerns with respect to our project. Thank you again for taking the time out of your busy schedules to participate in the consultation process. Your time, energy and input are an invaluable contribution to our project. Kris Cramer, our project coordinator, will contact each of you shortly to arrange telephone interviews.

Sincerely,

Terry Klassen

Appendix D: Questions for Individual Stakeholder Meetings

1. What are your impressions of computer-based evidence delivery systems?

2. If computer-based delivery systems are found to be effective what is the next logical step in the research process?

3. What are the gaps in medical informatics research? What information would have the greatest impact on policy and decision-making?

4. How would you suggest researchers approach filling these gaps?

5. What are the strengths and weaknesses of the existing state of knowledge with respect to these systems?

6. Who are the policy and decision makers that would find this information useful? How do we go about identifying these people?

7. How do we present and disseminate research findings so they will have the greatest impact on policy and decision makers.