Centre for Clinical Effectiveness

ENHANCING PATIENT OUTCOMES THROUGH CLINICAL APPLICATION OF THE BEST AVAILABLE EVIDENCE

EVIDENCE CENTRE CRITICAL APPRAISAL

How effective are computer assisted decision support systems (CADSS) in improving clinical outcomes of patients?

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Southern Health Care Network

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SUMMARY STATEMENT:

Publication of materials **–** please use the following format when citing this article: How effective are computer assisted decision support systems (CADSS) in improving clinical outcomes of patients? Southern Health/ Monash Institute of Public Health, Clayton, 2000. http://www.med.monash.edu.au/publichealth/cce

REQUEST:

How effective are computer assisted decision support systems (CADSS) in improving clinical outcomes of patients?

REQUESTED BY:

Bernard Yan, Neurology Research Fellow, Neurology Program, Monash Medical Centre, Clayton

METHODOLOGY

Search Strategy

The Centre for Clinical Effectiveness defined the 'best available evidence' as that research we can identify that is least susceptible to bias. We determine this according to pre-defined NHMRC criteria (see Appendix).

First we search for systematic reviews, evidence-based clinical practice guidelines, or health technology assessments, and randomized controlled trials. If we identify sound, relevant material of this type, the search stops. Otherwise, our search strategy broadens to include studies that are more prone to bias, less generalizable, or have other methodologic difficulties. We include case-control and longitudinal cohort studies in our critical appraisal reports. While we cite observational and case series studies, and narrative reviews and consensus statements, in our reports we do not critically appraise them. Some studies can produce accurate results but they are generally too prone to bias to allow determination of their validity beyond their immediate setting.

Details of Evidence Request:

Search terms:

The following search terms were used to scour electronic databases and websites:

Table 1. Search terms used in the retrieval of articles from electronic databases and websites

Field of focus	Search term
"CADSS"-related	Decision support systems clinical, decision making computer assisted, reminder systems, computer, clinical decision making, clinical algorithm
"RCT"-related	Randomised controlled trial, meta analysis, controlled clinical trial, clinical trial/s, random/ly/ised/ized, double or single blind, crossover/ studies

Resources Searched

We searched the following databases:

Cochrane Library CD-ROM, 2000, Issue 3

OVID Best Evidence, 1995 – March/April 2000

OVID Medline, 1995 – October Week 3 2000

OVID CINAHL, 1995 – July 2000

Ovid Current Contents, 1995 Week 26 to 2000 Week 37

Pre-Medline- September 1, 2000

SUMsearch- September 4, 2000

Effective Health Care Bulletins- 19 September, 2000

Effectiveness Matters- 19 September, 2000

Aggressive Research Intelligence Facility (ARIF)

Turning Research into Practice (TRIP)

Refinements, Searching & Reporting Constraints:

We included items of evidence that were available to us on 19 September, 2000. We only included articles published in English. Due to the identification of level I evidence (ranging from 1992-1999) we only searched for Level II evidence in the years 1999-2000.

RESULTS:

From our sources we identified 10 suitable articles which we categorised as follows:

Table 2. Study designs of articles retrieved by search

Study Design	Number included
Systematic reviews or meta-analyses	6
Randomised controlled trials	4
Total	**10**

We excluded the following 27 articles for the reasons listed:

Table 3. Reasons for exclusion of articles retrieved by search

Reason for exclusion	Number
Level IV evidence	
Cross sectional studies	1
Narrative reviews	9
Pre-post studies	3
Other reasons	
Continuing education focus	7
Not strictly a CDSS	3
Patient centred computer support	2
Not about patient outcomes/ physician performance	2
Total	**27**

This left 10 studies available for critical appraisal- 6 systematic reviews, and 4 randomised controlled trials. We are reasonably confident these articles represent the most important findings published to date based on our refinements, searching and reporting constraints.

REFERENCES

1. National Health and Medical Research Council. A Guide to the Development, Implementation and Evaluation of Clinical Practice Guidelines. Canberra: Commonwealth of Australia, 1999.

ARTICLES CRITICALLY APPRAISED FOR THIS REPORT

Level I evidence- Systematic Reviews

Balas, E. A., S. M. Austin, et al. (1996). "The clinical value of computerized information services. A review of 98 randomized clinical trials." Arch Fam Med **5**(5): 271-8.
OBJECTIVE: To review all randomized clinical trials addressing the efficacy of clinical information systems and to determine the clinical settings, types of interventions, and effects studied. DATA SOURCES: Extensive and systematic MEDLINE searches were conducted using a combination of medical subject headings (MeSH) and textword terms to collect trial reports. Manual searches of books and monographs as well as informal contacts were also used. STUDY SELECTION: The eligibility criteria were (1) randomized controlled clinical trial, (2) computerized information intervention in the study group, and (3) effect measured on the process or outcome of care. DATA EXTRACTION: Two research assistants independently abstracted from the selected reports the following structured information: trial sites, computerized interventions, effect variables, and outcomes. Three investigators evaluated the combined list of trial features for setting, intervention, and effect. The statistical analysis included an evaluation of agreement in developing classifications and an analysis of the ratio of positive trial outcomes. DATA SYNTHESIS: Most information services were tested in outpatient care (82%), particularly in primary care (66%). The information intervention targeted the provider in 64% of the trials. The effect was primarily measured for the process of care (76%). Provider prompt/reminder, computer-assisted treatment planner, interactive patient education/therapy, and patient prompt/reminder were significantly successful interventions (sign test, $P < .05$). CONCLUSIONS: Randomized clinical trials confirm that four generic information interventions are active ingredients of computer systems and can make a significant difference in family medicine (physician and patient reminders, treatment planner, and patient education). To manage care and improve quality, primary care computer systems should incorporate these effective information services.

Hunt, D. L., R. B. Haynes, et al. (1998). "Effects of computer-based clinical decision support systems on physician performance and patient outcomes: a systematic review [see comments]." JAMA **280**(15): 1339-46.
CONTEXT: Many computer software developers and vendors claim that their systems can directly improve clinical decisions. As for other health care interventions, such claims should be based on careful trials that assess their effects on clinical performance and, preferably, patient outcomes. OBJECTIVE: To systematically review controlled clinical trials assessing the effects of computer-based clinical decision support systems (CDSSs) on physician performance and patient outcomes. DATA SOURCES: We updated earlier reviews covering 1974 to 1992 by searching the MEDLINE, EMBASE, INSPEC, SCISEARCH, and the Cochrane Library bibliographic databases from 1992 to March 1998. Reference

lists and conference proceedings were reviewed and evaluators of CDSSs were contacted. STUDY SELECTION: Studies were included if they involved the use of a CDSS in a clinical setting by a health care practitioner and assessed the effects of the system prospectively with a concurrent control. DATA EXTRACTION: The validity of each relevant study (scored from 0-10) was evaluated in duplicate. Data on setting, subjects, computer systems, and outcomes were abstracted and a power analysis was done on studies with negative findings. DATA SYNTHESIS: A total of 68 controlled trials met our criteria, 40 of which were published since 1992. Quality scores ranged from 2 to 10, with more recent trials rating higher (mean, 7.7) than earlier studies (mean, 6.4) (P<.001). Effects on physician performance were assessed in 65 studies and 43 found a benefit (66%). These included 9 of 15 studies on drug dosing systems, 1 of 5 studies on diagnostic aids, 14 of 19 preventive care systems, and 19 of 26 studies evaluating CDSSs for other medical care. Six of 14 studies assessing patient outcomes found a benefit. Of the remaining 8 studies, only 3 had a power of greater than 80% to detect a clinically important effect. CONCLUSIONS: Published studies of CDSSs are increasing rapidly, and their quality is improving. The CDSSs can enhance clinical performance for drug dosing, preventive care, and other aspects of medical care, but not convincingly for diagnosis. The effects of CDSSs on patient outcomes have been insufficiently studied.

Johnston, M. E., K. B. Langton, et al. (1994). "Effects of computer-based clinical decision support systems on clinician performance and patient outcome. A critical appraisal of research [see comments]." Ann Intern Med **120**(2): 135-42.
OBJECTIVE: To review the evidence from controlled trials of the effects of computer-based clinical decision support systems (CDSSs) on clinician performance and patient outcomes. DATA SOURCES: The literature in the MEDLARS, EMBASE, SCISEARCH, and INSPEC databases was searched from 1974 to the present. Conference proceedings and reference lists of relevant articles were reviewed. Evaluators of CDSSs were asked to identify additional studies. STUDY SELECTION: 793 citations were examined, and 28 controlled trials that met predefined criteria were reviewed in detail. DATA EXTRACTION: Study quality was assessed, and data on setting, clinicians and patients, method of allocation, computer system, and outcomes were abstracted and verified using a structured form. Separate summaries were prepared for physician and patient outcomes. Within each of these categories, studies were classified further according to the primary purpose of the CDSS: drug dose determination, diagnosis, or quality assurance. RESULTS: Three of 4 studies of computer-assisted dosing, 1 of 5 studies of computer-aided diagnosis, 4 of 6 studies of preventive care reminder systems, and 7 of 9 studies of computer-aided quality assurance for active medical care that assessed clinician performance showed improvements in clinician performance using a CDSS. Three of 10 studies that assessed patient outcomes reported significant improvements. CONCLUSIONS: Strong evidence suggests that some CDSSs can improve physician performance. Additional well-designed studies are needed to assess their effects and cost-effectiveness, especially on patient outcomes.

Montgomery, A. A. and T. Fahey (1998). "A systematic review of the use of computers in the management of hypertension." J Epidemiol Community Health **52**(8): 520-5.
STUDY OBJECTIVE: To assess the effect of computers and computer-based clinical decision support systems on the management of hypertension. DESIGN: Systematic review of randomised controlled trials. SETTING: Ambulatory hypertension clinics, community-based health centres, and general practices. PARTICIPANTS: 11,962 patients enrolled in seven trials retrieved from a systematic search (electronic databases, contact with authors, reference lists; no restriction on language). MAIN RESULTS: Individual trials report on a diverse

population of patients (newly diagnosed or established hypertensive patients), interventions (computers used for case finding, recall and registration, feedback on quality of blood pressure control and prescribing information), and outcomes (administration, physician performance and blood pressure control). Four of five trials reported an improvement in patient administration using a computer. Two of three trials reported an improvement in physician performance using a computer. Two of six trials. reported an improvement in blood pressure control in patients using a computer. However, positive findings in two trials should be regarded cautiously because of the potential effects of cluster randomisation. CONCLUSIONS: It seems that computers have a favourable effect on the uptake and follow up of patients in hypertension management. The effect of computers on physician knowledge, recording of information, and blood pressure control in patients is less conclusive and further studies are required.

Shea, S., W. DuMouchel, et al. (1996). "A meta-analysis of 16 randomized controlled trials to evaluate computer-based clinical reminder systems for preventive care in the ambulatory setting [see comments]." J Am Med Inform Assoc **3**(6): 399-409. OBJECTIVE: Computer-based reminder systems have the potential to change physician and patient behaviors and to improve patient outcomes. We performed a meta-analysis of published randomized controlled trials to assess the overall effectiveness of computer-based reminder systems in ambulatory settings directed at preventive care. DESIGN: Meta-analysis. SEARCH STRATEGY: Searches of the Medline (1966-1994), Nursing and Allied Health (1982-1994), and Health Planning and Administration (1975-1994) databases identified 16 randomized, controlled trials of computer-based reminder systems in ambulatory settings. STATISTICAL METHODS: A weighted mixed effects model regression analysis was used to estimate intervention effects for computer and manual reminder systems for six classes of preventive practices. MAIN OUTCOME MEASURE: Adjusted odds ratio for preventive practices. RESULTS: Computer reminders improved preventive practices compared with the control condition for vaccinations (adjusted odds ratio [OR] 3.09; 95% confidence interval [CI] 2.39-4.00), breast cancer screening (OR 1.88; 95% CI 1.44-2.45), colorectal cancer screening (OR 2.25; 95% CI 1.74-2.91), and cardiovascular risk reduction (OR 2.01; 95% CI 1.55-2.61) but not cervical cancer screening (OR 1.15; 95% CI 0.89-1.49) or other preventive care (OR 1.02; 95% CI 0.79-1.32). For all six classes of preventive practices combined the adjusted OR was 1.77 (95% CI 1.38-2.27). CONCLUSION: Evidence from randomized controlled studies supports the effectiveness of data-driven computer-based reminder systems to improve prevention services in the ambulatory care setting.

Walton, R., S. Dovey, et al. (1999). "Computer support for determining drug dose: systematic review and meta-analysis." Bmj **318**(7189): 984-90. OBJECTIVE: To review the effectiveness of computer support for determining optimum drug dose. DESIGN: Systematic review of comparative studies where computers gave advice to clinicians on the most appropriate drug dose. Search methods used were standard for the Cochrane Collaboration on Effective Professional Practice. SUBJECTS: Comparative studies conducted worldwide and published between 1966 and 1996. MAIN OUTCOME MEASURES: For qualitative review, relative percentage differences were calculated to compare effects of computer support in different settings. For quantitative data, effect sizes were calculated and combined in meta-analyses. RESULTS: Eighteen studies met the inclusion criteria. The drugs studied were theophylline, warfarin, heparin, aminoglycosides, nitroprusside, lignocaine, oxytocin, fentanyl, and midazolam. The computer programs used individualised pharmacokinetic models to calculate the most appropriate dose. Meta-analysis of data from 671 patients showed higher blood concentrations of drug with computer support (effect size 0.69, 95% confidence interval 0.36 to 1.02) and reduced time to achieve therapeutic control

(0.44, 0.17 to 0.71). The total dose of drug used was unchanged, and there were fewer unwanted effects of treatment. Five of six studies measuring outcomes of care showed benefit from computer assistance. CONCLUSIONS: This review suggests that using computers to determine the correct dose of certain drugs in acute hospital settings is beneficial. Computers may give doctors the confidence to use higher doses when necessary, adjusting the drug dose more accurately to individual patients. Further research is necessary to evaluate the benefits in general use

Level II evidence- Randomised Controlled Trials

Cannon, D. S. and S. N. Allen (2000). "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 **7**(2): 196-203.
OBJECTIVE: To evaluate the relative effectiveness of computer and manual reminder systems on the implementation of a clinical practice guideline. DESIGN: Seventy-eight outpatients in a mental health clinic were randomly assigned within clinician to one of the two reminder systems. The computer system, called CaseWalker, reminded clinicians when guideline-recommended screening for mood disorder was due, ensured the fidelity of the diagnosis of major depressive disorder to criteria of the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV), and generated a progress note. The manual system was a checklist inserted in the paper medical record. MEASURES: Screening rates for mood disorder and the completeness of the documentation of which DSM-IV criteria were met by patients who were said to have major depressive disorder were compared. RESULTS: The CaseWalker, compared with the paper checklist, resulted in a higher screening rate for mood disorder (86.5 vs. 61 percent, P = 0.008) and a higher rate of complete documentation of DSM-IV criteria (100 vs. 5.6 percent, P < 0.001). CONCLUSIONS: In an outpatient mental health clinic, computer reminders were shown to be superior to manual reminders in improving adherence to a clinical practice guideline for depression.

Dayton, C. S., J. S. Ferguson, et al. (2000). "Evaluation of an Internet-based decision-support system for applying the ATS/CDC guidelines for tuberculosis preventive therapy [see comments]." Medical Decision Making **20**(1): 1-6.
Preventive therapy for patients infected with tuberculosis (TB) remains an important component of TB control. To guide physicians in applying preventive therapy, the American Thoracic Society and Centers for Disease Control (ATS/CDC) developed guidelines based on PPD reactivity and on pretest probability of infection. The guidelines have become complex, and many clinicians find them challenging to apply. The authors developed a computerized decision-support system to assist clinicians in applying the ATS/CDC guidelines. This tool, published on the World Wide Web using hypertext markup language, delivers patient-specific recommendations based on physician-delivered patient-specific information. Four local TB experts derived eight TB infection scenarios and validated the web-based tool, which was tested for effectiveness using general internal medicine residents, randomly divided into two groups. Group A (n = 12) used the web-based tool and group B (n = 17) used pre-existing understanding of the guidelines and/or written resources to determine the need for preventive therapy in the case scenarios. Group A correctly used therapy in 92/96 possible cases (95.8%), group B in only 77/136 (56.6%) (p < 0.001). Group A required a mean of three mouse-clicks and 1.5 minutes per scenario to reach their choices, and they rated the web-based tool both intuitive and effective. These data demonstrate that a computer-based decision-support system for applying TB treatment guidelines can be delivered over the Internet and provide an efficient and effective resource for clinicians.

East, T. D., L. K. Heermann, et al. (1999). “Efficacy of computerized decision support for mechanical ventilation: results of a prospective multi-center randomized trial.” Proceedings / AMIA Annual Symposium: 251-5.
200 adult respiratory distress syndrome patients were included in a prospective multicenter randomized trial to determine the efficacy of computerized decision support. The study was done in 10 medical centers across the United States. There was no significant difference in survival between the two treatment groups (mean 2 = 0.49 p = 0.49) or in ICU length of stay between the two treatment groups when controlling for survival (F(1df) = 0.88, p = 0.37.) There was a significant reduction in morbidity as measured by multi-organ dysfunction score in the protocol group (F(1df) = 4.1, p = 0.04) as well as significantly lower incidence and severity of overdistension lung injury (F(1df) = 45.2, p < 0.001). We rejected the null hypothesis. Efficacy was best for the protocol group. Protocols were used for 32,055 hours (15 staff person years, 3.7 patient years or 1335 patient days). Protocols were active 96% of the time. 38,546 instructions were generated. 94% were followed. This study indicates that care using a computerized decision support system for ventilator management can be effectively transferred to many different clinical settings and significantly improve patient morbidity.

Montgomery, A. A., T. Fahey, et al. (2000). “Evaluation of computer based clinical decision support system and risk chart for management of hypertension in primary care: randomised controlled trial.” BMJ **320**(7236): 686-90.
OBJECTIVES: To investigate the effect of a computer based clinical decision support system and a risk chart on absolute cardiovascular risk, blood pressure, and prescribing of cardiovascular drugs in hypertensive patients. DESIGN: Cluster randomised controlled trial. SETTING: 27 general practices in Avon. PARTICIPANTS: 614 patients aged between 60 and 79 years with high blood pressure. INTERVENTIONS: Patients were randomised to computer based clinical decision support system plus cardiovascular risk chart; cardiovascular risk chart alone; or usual care. MAIN OUTCOME MEASURES: Percentage of patients in each group with a five year cardiovascular risk >/=10%, systolic blood pressure, diastolic blood pressure, prescribing of cardiovascular drugs. RESULTS: Patients in the computer based clinical decision support system and chart only groups were no more likely to have cardiovascular risk reduced to below 10% than patients receiving usual care. Patients in the computer based clinical decision support group were more likely to have a cardiovascular risk >/=10% than chart only patients, odds ratio 2.3 (95% confidence interval 1.1 to 4.8). The chart only group had significantly lower systolic blood pressure compared with the usual care group (difference in means -4.6 mm Hg (95% confidence interval -8.4 to -0.8)). Reduction of diastolic blood pressure did not differ between the three groups. The chart only group were twice as likely to be prescribed two classes of cardiovascular drugs and over three times as likely to be prescribed three or more classes of drugs compared with the other groups. CONCLUSIONS: The computer based clinical decision support system did not confer any benefit in absolute risk reduction or blood pressure control and requires further development and evaluation before use in clinical care can be recommended. Use of chart guidelines are associated with a potentially important reduction in systolic blood pressure.

ARTICLES NOT CRITICALLY APPRAISED / EXCLUDED

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APPENDIX

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The information in this report is a summary of that available and is primarily designed to give readers a starting point to consider currently available research evidence. Whilst appreciable care has been taken in the preparation of the materials included in this publication, the authors and Southern Health Care Network do not warrant the accuracy of this document and deny any representation, implied or expressed, concerning the efficacy, appropriateness or suitability of any treatment or product. In view of the possibility of human error or advances of medical knowledge the authors and Southern Health Care Network cannot and do not warrant that the information contained in these pages is in every aspect accurate or complete. Accordingly, they are not and will not be held responsible or liable for any errors of omissions that may be found in this publication. You are therefore encouraged to consult other sources in order to confirm the information contained in this publication and, in the event that medical treatment is required, to take professional expert advice from a legally qualified and appropriately experienced medical practitioner.

Levels Of Evidence

As Defined By "A Guide To The Development, Implementation And Evaluation Of Clinical Practice Guidelines" (National Health & Medical Research Council, Canberra, 1998):

Level I		Evidence obtained from a systematic review or meta-analysis of all relevant randomised controlled trials.
Level II		Evidence obtained from at least one properly designed randomised controlled trials.
Level III	-1	Evidence obtained from well-designed pseudo-randomised controlled trials (alternate allocation or some other method).
	-2	Evidence obtained from comparative studies with concurrent controls and allocation not randomised (cohort studies), case control studies or interrupted time series with a control group.
	-3	Evidence obtained from comparative studies with historical control, two or more single-arm studies or interrupted time series without a parallel control group.
Level IV		Evidence obtained from case series (either post-test or pre-test and post-test), opinions of respected authorities (narrative reviews), descriptive studies, reports of expert (i.e. consensus) committees, case studies.

Evidence Summary Systematic Review How effective are computer assisted decision support systems (CADSS) in improving clinical outcomes of patients?	**Study 1** **Balas EA et al, 1996** **The clinical value of computerized information services**	**Study 2** **Johnston ME et al, 1994** **Effects of computer-based clinical decision support systems on clinician performance and patient outcome.**
STUDY DESIGN & NHMRC LEVELS OF EVIDENCE	Systematic Review Level I evidence	Systematic Review Level I evidence
DESCRIPTION: Subjects, Interventions, Comparisons, Outcomes, Inclusion & Exclusion Criteria	**(Patients)Subjects:** Clinicians **Intervention:** Clinical information services **Comparison:** No computer assistance **Outcomes:** Process and or outcome of care **Exclusion criteria**: studies that were not randomised controlled trials	**(Patients)Subjects:** Clinicians in practice or training **Intervention:** Computer based CDSS **Comparison:** Care without a computer based CDCC **Outcomes:** Clinician performance, process of care or patient outcomes. **Exclusion criteria:** Studies that were not prospective and without control groups. Studies lacking a control group where patient care with a CDSS was compared with patient care without one.
VALIDITY: Methodology, rigour, selection, opportunity for bias	**Search strategy:** MEDLINE searches, years not specified. Manual searching and contact with "experts". Language not specified. **Assessed validity:** Independent reviewers assed validity only as an inclusion/ exclusion process and there is no statement of the quality of the included studies. **Consistent results:** Uncertain, no tests of heterogeneity reported **Potential for bias:** Trials that did not scored a mean below minus 2 standard deviations on the quality evaluation tool were not included in the review. Potentially narrow search strategy meaning that studies may have been missed. Unclear inclusion and exclusion criteria.	**Search strategy:** MEDLINE from Jan 1983 to 1992, EMBASE, INSPEC, SCISEARCH and manual searching for all languages. **Assessed validity:** Two reviewers independently rated the studies on 5 potential sources of bias. **Consistent results:** Yes. Tests of heterogeneity are reported for drug dose determination and quality of preventative care. **Potential for bias:** Randomised trials of CDSS are unable to blind providers, and often the separation of control and intervention groups is difficult therefore contamination is an issue. Some trials had a small sample size. Potential publication bias, meaning that all unpublished studies may not have been identified.
RESULTS: Generally favourable or unfavourable, specific outcomes of interest, estimate of experimental effect and precision if appropriate	98 articles were reviewed. These articles included inpatient and outpatient settings. Process outcomes were the main outcomes of most of the studies (76%). In those studies that evaluated provider prompt/reminders, 19% showed a positive result; likewise a positive result was found in 79% of studies evaluating computer-assisted treatment planners, 74% of studies evaluating interactive patient education/therapy, and 80% of studies looking at patient/prompt reminders. Only 27 studies evaluated outcome measures (other than process of care), these included measures of patient knowledge, attitudes, morbidity, physiology and psychology. 85% of those studies that measured patient knowledge and attitudes showed a positive result, and 71% of studies measuring morbidity, physiology or psychology found positive results.	28 controlled trials were identified and reviewed in detail. Trials were conducted in both inpatient and outpatient settings, and Three of 4 studies of computer-assisted dosing reported statistically significant improvements in achieving therapeutic levels. Significant heterogeneity was noted among the results ($p=0.0002$). 1 of 5 studies of computerised decision aids showed a positive effect for diagnosis. 4 of 6 studies of CDSSs that were designed to enhance the quality of preventative care showed statistically significant effects on clinician performance. Significant heterogeneity was observed among results from these 5 studies ($p<0.001$). 7 of 9 studies that assessed the effect of CDSSs on clinician performance in caring for active medical problems reported statistically significant effects on medical care processes. Three of 10 studies that assessed patient outcomes reported

		significant improvements."
AUTHORS COMMENTS: Risk/benefit, limitations	"Randomized clinical trials confirm that four generic information systems are active ingredients of computer systems and can make a significant difference in family medicine (physician and patient reminders, treatment planner, and patient education). To manage care and improve quality, primary care computer systems should incorporate these effective information services."	"Strong evidence suggests that some CDSS's can improve physician performance. Additional well-designed studies are needed to assess their effects and cost-effectiveness, especially on patient outcomes."
REVIEWER'S COMMENTS: Risk/benefit, methodology, conclusions	Unclear inclusion and exclusion criteria, and a narrow search strategy. The quality of included studies was no systematically studied.	Well-conducted review.

Evidence Summary Systematic Review How effective are computer assisted decision support systems (CADSS) in improving clinical outcomes of patients?	**Study 3** **Shea S. et al, 1996** **A meta-analysis of 16 randomised controlled trials to evaluate computer-based clinical reminder systems for preventative care in the ambulatory setting**	**Study 4** **Montgomery AA. et al, 1998** **A systematic review of the use of computers in the management of hypertension**
STUDY DESIGN & NHMRC LEVELS OF EVIDENCE	Systematic Review Level I evidence	Systematic Review Level I evidence
DESCRIPTION: Subjects, Interventions, Comparisons, Outcomes, Inclusion & Exclusion Criteria	**(Patients)Subjects:** Physicians and patients **Intervention:** Computerised reminder systems **Comparison:** Paper based/ manual reminders and control of no reminder at all. **Outcomes:** Vaccinations, breast cancer screening, colorectal cancer screening, cardiovascular risk reduction, cervical cancer screening, preventative care. **Exclusion criteria**: Studies of non-computerised reminder systems, studies using historical controls. Only randomised controlled studies were included.	**(Patients)Subjects:** **Intervention:** Patient care of hypertension using a CDSS **Comparison:** Patient care of hypertension without a CDSS **Outcomes:** patient uptake. Administration, physician performance, blood pressure control achieved in hypertensive patients. **Exclusion criteria:** excluded studies that were not randomised controlled trials, only included studies that defined a CDSS as an active knowledge system that uses two or more items of patient data to generate case specific advice. Excluded studies not dealing with hypertension
VALIDITY: Methodology, rigour, selection, opportunity for bias	**Search strategy:** Medline, nursing and allied health, and health planning and administration databases from 1966-1995. Language not specified. No reference made to hand searching or contacting authors. Search terms are specified. **Assessed validity:** There was no systematic assessment of the validity of the included studies. **Consistent results:** Uncertain, no tests of heterogeneity reported **Potential for bias:** We are unclear of the quality of the included studies. We are also unclear of whether it is patients or physicians who are using the computer systems in each study, and there is no definite criteria for studies being included/excluded.	**Search strategy:** Cochrane, Medline, BIDS, EMBASE from 1966 to 1997. Search terms specified, included hand searching and non-English articles. **Assessed validity:** Two authors independently reviewed articles for a number of different biases, following the Cochrane quality criteria. **Consistent results:** Uncertain, no tests of heterogeneity reported. **Potential for bias:** Good search strategy and assessment of validity. Potential for publication bias, indicating that studies with negative results that were not published may not have been included.
RESULTS: Generally favourable or unfavourable, specific outcomes of interest, estimate of experimental effect and precision if appropriate	Computer reminders improved preventative practices compared with control condition for vaccinations (OR 3.09, CI 2.39-4.00), breast cancer screening (OR 1.88, CI 1.44-2.45), colorectal cancer screening (OR 2.25, CI 1.74-2.91), and cardiovascular risk reduction (OR 2.01, CI 1.55-2.61) but not cervical cancer screening (OR 1.15, CI 0.89-1.49) or other preventative care (OR 1.02, CI 0.79-1.32). For all six classes of preventative practices combined the adjusted OR was 1.77 (95% CI 1.38-2.27).	Seven randomised controlled trials were identified. 4 of 5 trials reported an improvement in physician performance using a computer. Two trials reported an improvement in the recording of blood pressure in the notes in patients in the computer group versus control group (P values of <0.001 and <0.05). Two studies reported that patients in the computer group received more follow up (p value <0.05), while another study found no difference in follow up between groups (P>0.05). Physician knowledge did not significantly differ between the computer and control groups in one study (p=0.025). There was significantly more recording in

		the medical record in the computerised group compared to the control group ($p<0.001$). Computer generated treatment recommendations provided no advantage in prescribing. Two studies reported a greater percentage of patients in the computer group having controlled blood pressure.
AUTHORS COMMENTS: Risk/benefit, limitations		"It seems that computers have a favourable effect on the uptake and follow up of patients in hypertension management. The effect of computers on physician knowledge, recording of information, and blood pressure control in patients is less conclusive and further studies are required"
REVIEWER'S COMMENTS: Risk/benefit, methodology, conclusions		Thorough review with low potential for bias

Evidence Summary Systematic Review How effective are computer assisted decision support systems (CADSS) in improving clinical outcomes of patients?	**Study 5** **Walton R et al, 1999** **Computer support for determining drug dose: systematic review and meta-analysis**	**Study 6** **Hunt DL. et al, 1998** **Effects of computer-based clinical decision support systems on physician performance and patient outcomes.**
STUDY DESIGN & NHMRC LEVELS OF EVIDENCE	Systematic review and meta-analysis Level I evidence	Systematic Review Level I evidence
DESCRIPTION: Subjects, Interventions, Comparisons, Outcomes, Inclusion & Exclusion Criteria	**(Patients)Subjects:** Clinicians **Intervention:** Computers to determine drug dose **Comparison:** Unassisted decisions or decisions made using aids such as monograms, or computers directly administering the drug to patients **Outcomes:** drug dose changes, unwanted effects of treatment, blood concentrations of drug or physiological measurement, time to achieve therapeutic control, improved outcome, changes in cost. **Exclusion criteria:** Studies where the computer simply suggested giving or withholding a drug.	**(Patients)Subjects:** Health professionals in clinical practice **Intervention:** Computer based clinical decision support systems **Comparison:** Care without CDSS **Outcomes:** physician performance, patient outcomes **Exclusion criteria:** Only included studies that assessed physician performance or patient outcomes, studies that did not include a contemporaneous control group were excluded.
VALIDITY: Methodology, rigour, selection, opportunity for bias	**Search strategy:** Cochrane, Medline and Embase (1966 to June 1996). Search terms were specified. Follow up from references, and contact with experts. Language not specified. **Assessed validity:** Two researchers reviewed each study independently. Assessment and scoring of a number of potential sources of bias using their own assessment tool. **Consistent results**: Uncertain, no tests of heterogeneity reported **Potential for bias:** The review included comparative studies of lower level evidence, and reviewers identified that many of the included studies were of poor quality. Not all studies measured all of the outcomes. Potential publication bias.	**Search strategy**: Medline, EMBASE, INSPEC, SCISEARCH from 1974 to 1998. Also searched reference lists and contacted authors. All languages. **Assessed validity:** Two independent reviewers assessed each paper on a 10 point rating scale addressing 5 potential biases. **Consistent results:** Uncertain, no tests of heterogeneity reported **Potential for bias:** Low potential for bias, possible contamination of users. Potential for publication bias.
RESULTS: Generally favourable or unfavourable, specific outcomes of interest, estimate of experimental effect and precision if appropriate	18 studies were identified and reviewed. Meta-analysis of data from 671 patients showed higher blood concentrations of drug with computer support and reduced time to achieve therapeutic control than in the control groups. The total dose of drug used was unchanged, and there were fewer unwanted effects of treatment. Five of six studies measuring outcomes of care showed benefit from computer assistance compared to no computer assistance.	Effects on physician performance were assessed in 65 studies and 43 found benefit (66%). These included 9 of 15 studies on drug dosing systems, 1 of 5 studies on diagnostic aids, 14 of 19 preventive care systems, and 19 0f 26 studies evaluating CDSSs for other medical care. Six of 14 studies assessing patient outcomes found a benefit. Of the remaining 8 studies, only 3 had power of greater than 80% to detect a clinically important effect.
AUTHORS COMMENTS: Risk/benefit, limitations	"This review suggests that using computers to determine the correct dose of certain drugs in acute hospital settings is beneficial. Computers may give doctors the confidence to use higher doses when necessary, adjusting the drug dose more accurately to individual patients. Further research is necessary to evaluate the benefits of	"Published studies of CDSS's are increasing rapidly, and their quality is improving. The CDSSs can enhance clinical performance for drug dosing, preventive care, and other aspects of medical care, but not convincingly for diagnosis. The effects of CDSSs on patient outcomes have been insufficiently studied.

	general use."	
REVIEWER'S COMMENTS: Risk/benefit, methodology, conclusions	The main limitation of this review is that the studies they included were of low-level evidence.	Very thorough review, especially the assessment of the quality of the included studies.

Evidence Summary Therapy How effective are computer assisted decision support systems (CADSS) in improving clinical outcomes of patients?	**Study 1** **East TD. et al, 1999** **Efficacy of computerized decision support for mechanical ventilation: results of a prospective multi-centre randomised trial**	**Study 2** **Cannon DS. Et al, 2000** **A comparison of the effects of computer and manual reminders on compliance with a mental health clinical practice guideline**
STUDY DESIGN & NHMRC LEVELS OF EVIDENCE	RCT Level II evidence	RCT Level II evidence
DESCRIPTION: Subjects, Interventions, Comparisons, Outcomes, Inclusion & Exclusion Criteria	**Subjects (Patients):** adult respiratory distress syndrome (ARDS) patients **Intervention:** Protocol control **Comparison:** Non protocol control **Outcome:** Survival, costs, morbidity, iatrogenic injury, % of time that protocols controlled patient care, number of protocol instructions not followed, variation in performance. **Incl & Excl Criteria:** Included if arterial/alveolar partial pressure of O_2 ratio ≤0.3, total static thoracic compliance ≤50ml/cm H_2O, acute onset of illness accompanied by an ARDS risk factor, radiographic evidence of bilateral diffuse infiltrates. Excluded if evidence of heart failure or fluid overload, ARDS >21 days duration, severe chronic systemic disease or another clinical condition greatly limiting survival.	**Subjects (Patients):** Admissions newly referred to the outpatient clinic for post traumatic stress disorder. **Intervention:** Computer reminder system (the CaseWalker) reminding when guideline-recommended screening for mood disorder was due. **Comparison:** Paper checklist placed into patients' paper record, reminding when guideline-recommended screening for mood disorder was due. **Outcome:** Number of cases screened for mood disorder (MDD), proportion of cases for which the diagnosis of MDD was fully documented. **Incl & Excl Criteria:** Only patients who were seen by clinician at least two times were included to allow sufficient time to use the reminder.
VALIDITY: Methodology, rigour, selection, opportunity for bias	**Randomisation:** Yes, however, method of randomisation not specified. **All patients accounted for:** Yes **Patients treated equally:** Yes, although we are unclear of the details of the intervention and control treatment. **Similar groups:** Yes due to initial stratification **Potential for bias:** There is no clear description of the intervention itself (other than to say they used the same CDSS that had already been used in another trial), making it difficult to determine if the groups were in fact treated equally. Unclear method of randomisation.	**Randomisation:** 4 clinicians were randomised to one of two experimental conditions based on random number tables. Patients were non-randomly assigned to one of the 4 participating clinicians. **All patients accounted for:** Yes **Patients treated equally:** Potential differences between the 4 clinicians **Similar groups:** Unclear baseline characteristics of the two groups **Potential for bias:** The groups may not have been similar at the beginning of the trial, clinicians may not have treated patients equally, and assignment of patients to clinicians was not randomised.
RESULTS: Generally favourable or unfavourable, specific outcomes of interest, estimate of experimental effect and precision if appropriate	Protocols were active in 96% of cases for the intervention group and 94% of the instructions generated were followed. There was no significant difference in survival between the two treatment groups (p=0.49) or in ICU length of stay between the two treatment groups when controlling for survival (p=0.37). There was a significant reduction in morbidity in the protocol group (p=0.04) as well as	The CaseWalker compared with the paper checklist, resulted in a higher screening rate for mood disorder (p=0.008), and a higher rate of complete documentation of DSM_IV criteria (p<0.001), than those observed in the control group.

	significantly lower incidence and severity of overdistension lung injury ($p<0.001$).	
AUTHORS COMMENTS: Risk/benefit, limitations	"This study indicates that care using a computerised decision support system for ventilator management can be effectively transferred to many different clinical settings and significantly improve patient morbidity."	"In an outpatients mental health clinic, computer reminders were shown to be superior to manual reminders in improving adherence to a clinical practice guideline for depression".
REVIEWER'S COMMENTS: Risk/benefit, methodology, conclusions	Main limitation is that we are unable to replicate or verify these findings due to the unclear description of the intervention itself. The results are specific to patients with adult respiratory distress syndrome.	Patients were non-randomly assigned to clinicians. We still are unsure of whether more cases of MDD are diagnosed with the computer reminder or whether they are just better documented with the computer reminder. Cannot be sure that the two groups were the same at the commencement of the trial.

Evidence Summary Therapy How effective are computer assisted decision support systems (CADSS) in improving clinical outcomes of patients?	**Study 3** **Dayton CS. Et al , 2000** **Evaluation of an internet-based decision support system for applying the ATS/CDC guidelines for tuberculosis preventive therapy.**	**Study 4** **Montgomery AA. Et al, 2000** **Evaluation of computer based clinical decision support system and risk chart for management of hypertension in primary care: a randomised controlled trial**
STUDY DESIGN & NHMRC LEVELS OF EVIDENCE	RCT Level II evidence	RCT Level II evidence
DESCRIPTION: Subjects, Interventions, Comparisons, Outcomes, Inclusion & Exclusion Criteria	**Subjects (Patients):** General internal medicine residents participating at a conference **Intervention:** DSS for preventative therapy via the internet to assess 8 case scenarios **Comparison:** Paper based resources (any that they could access) and a guideline card to assess 8 case scenarios **Outcome:** Accurate decisions regarding preventative treatment, time to reach decision and user-rated ease of use. **Incl & Excl Criteria:** None specified	**Subjects (Patients):** Patients aged 60-80 with a diagnosis of hypertension. **Intervention:** Computer based clinical decision support system and a cardiovascular risk chart **Comparison:** A- Risk chart alone, B- usual care **Outcome:** Percentage of patients with 5 year cardiovascular risk ≥10%, Systolic and diastolic blood pressure, and prescribing of cardiovascular drugs. **Incl & Excl Criteria:** Patients must have a record of being prescribed antihypertensive drugs in the previous year. Excluding non-ambulatory patients, those with life threatening illness, and those who had recently had major surgery.
VALIDITY: Methodology, rigour, selection, opportunity for bias	**Randomisation:** Method of randomisation not specified **All patients accounted for:** Yes **Patients treated equally:** The guideline card group were also able to access any paper-based resources whereas the DSS group was not. **Similar groups:** No attempt to evaluate baseline characteristics, possible that residents differed in experience or training. **Potential for bias:** Potential differences between the groups at baseline, differences in instructions given, unclear method of randomisation and small sample size. Unclear inclusion and exclusion criteria.	**Randomisation:** Simple random allocation, using a table of random numbers. **All patients accounted for:** Yes **Patients treated equally:** Yes **Similar groups:** Practices were stratified according to which existing computer system they used. All 3 groups were similar on baseline measures. **Potential for bias:** Low potential for bias
RESULTS: Generally favourable or unfavourable, specific outcomes of interest, estimate of experimental effect and precision if appropriate	The DSS group correctly used therapy in 95.8% of the case scenarios, whereas the paper resources group correctly used therapy in 56.6% of case scenarios, the difference was significant ($p<0.001$). The DSS group took an average of 1.5 minutes per scenario to reach the choices, and they rated the web-based tool both intuitive and effective.	Cardiovascular (CV) risk reduced to below 10% was the same for both groups of patients. Patients in the CDSS group were more likely to have CV risk ≥10% than chart only patients (OR-2.3, CI 1.1-4.8). The chart only group had significantly lower systolic blood pressure compared with the usual group (difference in means –4.6mmHg CI –8.54to -0.8). Reduction of diastolic blood pressure did not differ between the 3 groups. The chart only group were twice as likely to be prescribed two classes of CV drugs (OR 0.5, CI 0.2-0.9) than the computer support plus chart group. The chart only group were over 3

		times as likely to be prescribed 3 or more classes of drugs compared with the computer support plus chart group (OR 0.3 CI 0.1-0.6).
AUTHORS COMMENTS: Risk/benefit, limitations	Authors conclude that these data demonstrate that a computer based DSS for applying TB treatment guidelines can be delivered over the internet and provide an efficient and effective resource for clinicians.	"The CDSS did not confer any benefit in absolute risk reduction or blood pressure control and requires further development and evaluation before use in clinical care can be recommended. Use of chart guidelines are associated with a potentially important reduction in systolic blood pressure."
REVIEWER'S COMMENTS: Risk/benefit, methodology, conclusions	Interpret with caution due to limitations in the methodology.	Well conducted study