Can computerised decision support systems deliver improved quality in primary care?

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Computerised decision support systems or "expert systems" are computer software systems that are designed to aid clinical decision making. Computerised decision support has been defined as provision of assessments or prompts specific to the patient and selected from a knowledge base on the basis of individual patient data.[1] At its simplest this definition will include programs that suggest alternatives for treatment or diagnosis on the basis of a simple algorithm. More complex systems model the likelihood of future events and the effectiveness of proposed interventions based on individual patient data and "knowledge" of risks and the effectiveness of interventions.[2]

Summary points

Computerised reminder and recall systems increase the frequency of monitoring and preventive tasks in the management of chronic disease

Computerised dosing systems for warfarin improve the control of anticoagulation

Computerised diagnostic decision support has not yet been developed to the stage where it can significantly aid diagnostic accuracy

There is a lack of research with patient oriented outcomes in this topic

Shared decision making between doctors and patients is an issue where computer systems may develop an important role

Primary care more than any other specialty is characterised by uncertainty. This is not only because it is the first point of contact and the recipient of undifferentiated problems, but also because primary care has the role of monitoring and providing optimal continuing care for many common chronic conditions. Improvement of quality by a reduction of the variation in primary care practice is a key component of UK national health policy.[3] Computerised decision support systems have potential to drive reminders, provide alerts for prescribing interactions or test results, interpret complex investigations (or electrocardiograms), predict mortality on the basis of epidemiological data, aid diagnosis, and calculate drug doses. The question examined by this review is how may computerised decision support systems contribute to improving quality in primary care?

The United Kingdom has the most extensively computerised primary healthcare sector in the world and has a unique opportunity to develop and evaluate this technology.[4] As the principal purpose of computerised decision support systems is to support clinical judgment and to provide the structures underlying continuing care, it is surprising that use of computerised decision support systems is not commonplace. The principal reasons for this have been a lack of agreed national standards, a failure of systems to examine the needs of users adequately, and the profusion of different systems that do not communicate with each other.[5] Recent mergers between suppliers, the development of national standards for coding and information exchange, and the latest generation of Windows based medical systems could enable the development of more sophisticated computerised decision support systems than the "electronic protocols" currently being used.[3] It would seem an appropriate point to consider the scope for computerised decision support systems in supporting quality primary care.

According to Buchanan and Smith[6] expert systems should

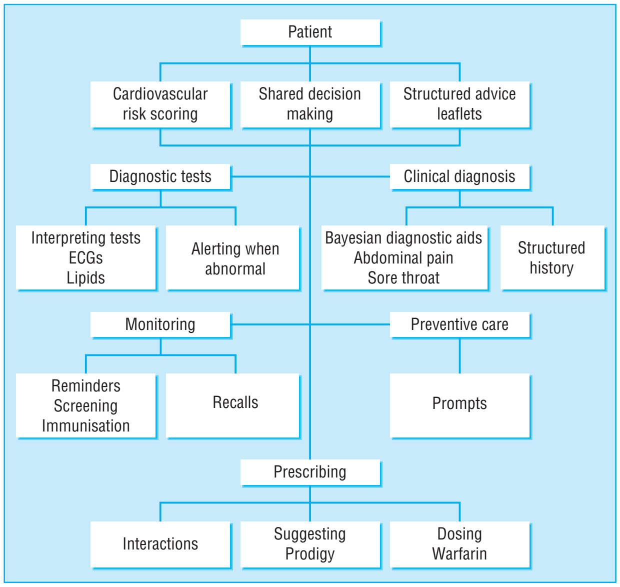
- Provide a solution at the same level of performance as a human expert
- Use symbolic and heuristic reasoning rather than numeric and algorithmic procedures
- Store knowledge separately from inference procedures
- Provide explanations of their reasoning.

Shortliffe has identified barriers to the use of decision support: lack of adequate theory, failure to recognise the needs of users, lack of sources of knowledge, and lack of system development.[7] The degree to which a system supports the process of the primary care consultation is paramount if the system is to be of use to general practitioners.[8]

The potential for computerised decision support systems in primary care

Primary care is in part distinguished by its role in the diagnosis of undifferentiated problems and in the continuing management of chronic disease. General practitioners work in teams with other healthcare professionals and view the process of sharing information and decisions about patient management with the patient as central to their discipline. There are many opportunities when computerised decision support systems can enhance the scope and reliability of these tasks (figure).

Most systems are concerned with discrete clinical situations—for example, assessment of risk in ischaemic heart disease[9] or the therapeutic management of oral anticoagulation.[10] A systematic review of computer based clinical decision support systems in 1993 found 28 controlled trials relating to computerised decision support systems categorised into the



Potential for computerised decision support in the primary care setting

topics of dosing, diagnosis, preventive care, and quality assurance.[11] This review has recently been updated and a further 40 trials added, many of these in the primary care setting.[1] The review concluded that "strong evidence exists that some computerised decision support systems can improve physician performance," particularly the use of preventive reminder systems and drug dosing. Sullivan and Mitchell have also conducted a systematic review but focusing on overall use of the computer in primary care. They assessed 30 evaluations, and found an increase in immunisation rates and other preventive tasks but a 90 second average increase in consultation length.[12]

Currently three types of expert system have been developed: rule based systems, probabilistic systems, and cognitive models.[13] At present no systems based on simulation models have been developed, but they are mentioned here on account of their potential.

Computerised decision support systems may support the primary care consultation in the following ways:

- By providing ready access to appropriate knowledge or protocols via patient specific prompts
- By providing a rational aid to diagnosis or probable outcome on the basis of patient specific data
- By involving patients explicitly in the decision making process.

Electronic protocols: rule based systems

Rule based systems present information in context and in response to a series of problem led prompts that may guide choice of drug, provide reminders, or suggest diagnostic strategies. Rules may be based on clinical or demographic characteristics, combinations of features, or results of previous steps. They may be more an aid to communication than to the logical application of knowledge and may be more or less explicit in the operation of the rules at any given point in the program—for example, by listing the rules under consideration.[14] Such systems promote learning and involvement in the diagnostic process and hence are likely to be used more than systems that hide their rules.

Rule based systems depend on the design of the knowledge base and inference system. Consensus statements may fail to provide clear advice for consistency, and locally agreed practice may fail to agree with national guidelines.[15] Rule based systems are, of need, conservative as they reflect the gradual accumulation of data and their assimilation into practice. They are sometimes more costly to update and by the time testing and marketing have taken place may already be outdated. In addition, much of the knowledge of specialists is highly context specific and may not be transferable to the primary care setting.[16]

One recent rule based development has been Prodigy (prescribing rationally with decision support in general practice study).[17 18] Prodigy provides decision support to general practitioners within consultations regarding prescribing. The development and evaluation of the system was commissioned by the NHS executive prescribing branch. The intention was to develop a system that would integrate with practice clinical systems and present appropriate drug choices according to the diagnosis. The choices were made by an "expert panel" and were evidence based in nature. The study showed a small restraining effect on inflation of drug budgets in the practices using the system. The validity and clinical and statistical significance of this result, however, has been questioned.[19] The project has now moved on to the production of accompanying patient information leaflets.

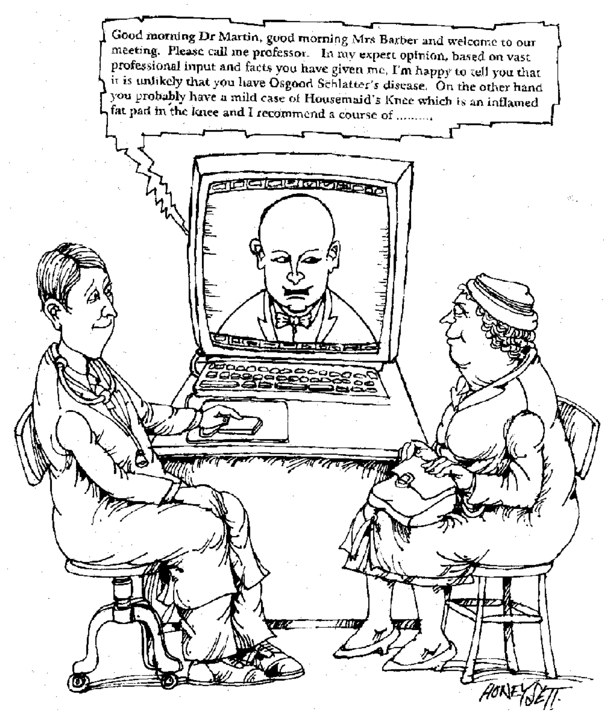
Although Prodigy is a good example of a rule based computerised decision support system designed specifically for primary care, it fails to examine the potential for such systems to increase the involvement of patients in clinical decisions and to develop inference beyond that available from an electronic formulary.

Expert systems: Bayesian systems and cognitive and simulation models

Probabilistic systems model patient data against epidemiological data to predict future events, either for prognostic or diagnostic purposes.[20] Such systems, however, are limited in two important topics: the availability of data and the complexity of possible outcomes. In many specialties in medicine the necessary information on prognostic implications is missing and in few specialties are true base rates available.[21]

Probabilistic systems, however, have the advantage of separating knowledge from inference and can be readily updated. An example of such a system is the cardiovascular "risk calculators," which are becoming a feature of primary prevention in practice. Rather than treating hypertension, smoking, or hyperlipidaemia in isolation, the risks of cardiovascular events or mortality can be calculated for individual patients by using the Framingham data.[9]

Simulation models such as discrete event simulation consider a system or reality in terms of states, with a change of



state referred to as an event.[22] An example of an event is a "healthy" person contracting a disease. In a simulation a patient's life cycle can be divided into a series of events and their passage determined by estimated probabilities. Similarly the time between events is based on research data, with events themselves defined as taking no time. The principal advantage of discrete event simulation is that the model can be broken down to the individual patient rather than a subgroup or cohort of patients. Therefore it is also possible to attach directly the resource use and cost of the individual patient. There is potential to build simulations in which the outcomes of different diagnostic or treatment strategies for individual patients can be compared and used as the knowledge base for computerised decision support systems.

Clinical guidance trees: involving patients

The concept of communication and sharing ideas and understanding is central to the primary care consultation.[23 24] This is fundamental to the biopsychosocial model of primary care and needs to be the basis for system development if computerised decision support systems are to be effective in primary care.

Decision analysis is a powerful mathematical tool that breaks a problem into its individual outcomes, assigning probabilities (chance) and utilities (values), allowing their combination to determine the choice of maximum expected utility.[25] A decision tree is drawn up by defining all possible outcomes of the given problem, the tree is structured over time and probabilities and utilities added.[26] The probabilities are the best estimate that can be obtained from the literature or from observation, the utilities may represent costs, effectiveness measures such as a symptom score, survival rate, or quality adjusted life years or be derived from a measure of patients' value of a given outcome.

Decision analysis explicitly incorporates uncertainty; if exact values are not available a range of values can be used in a sensitivity analysis. Chronic conditions can be modelled by using time dependent tools such as Markov modelling or discrete event simulation.[27] Dowie has proposed that tools based on decision analysis—termed clinical guidance trees—may be used to provide informed shared decision making.[14] A number of interactive patient decision tools—such as CD Roms and videos—have been developed but, as yet, none that combine patient values with clinical risks.

Conclusions

Computerised decision support systems have great potential for primary care but have largely failed to live up to their promise. This has been principally on account of a failure to examine the needs of practitioners adequately. Simple systems that operate prompts and reminders and dosing systems for warfarin, however, have been shown to improve the quality of process of care. Further research is needed on patient oriented outcomes to determine the cost effectiveness of developing such systems.

Sophisticated understanding of the process of the consultation is required to support decision making. It has been rightly pointed out that systems (like aviation design) do not develop via the randomised trial and that an iterative development and assessment programme, such as that used by the Prodigy team, is needed.[28] The benefits of air travel over sea, however, are considerably greater than the small effects sought by healthcare interventions. Randomised trials to compare the effectiveness of computerised decision support system driven care versus alternative interventions in specific clinical applications are needed to justify expenditure in this area. *JAMA* recently published a users' guide to the medical literature, which discussed evaluations of computerised decision support systems.[29] The authors emphasised that computerised decision support systems are a rapidly advancing and unregulated field, with potential for harm as well as benefit if systems are poorly designed and inadequately evaluated. The onus is on users to monitor the introduction of any new system carefully.

Without placing the patient at the centre of the system there is a danger that increasing technology will reduce rather than enhance the patient centred nature of care. Further, there is a risk that computerised decision support systems will be seen as "just a more sophisticated information tool" and the benefits of prediction and enhancing decision making will be missed. New NHS funding programmes such as the New and Emerging Applications of Technology Programme and the Information and Communication Technology Initiative should enable UK practitioners and developers to meet this challenge.

Competing interests: None declared.

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