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Decision support in clinical practice

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This chapter will help the reader to appreciate that:

- the clinician is the central element in the decision support and decision making process.
- there is a wide range of decision support to facilitate (NOT replace) clinical decision making.
- decision support systems can and should teach and learn with the clinician.
- the importance of accuracy, reliability and structure in the knowledge base and patient database.
- there are benefits and problems in the use of clinical decision support.

What is decision support?

Decision support is aimed at assisting professional activity. Clinical decision support is focused on the information required for and generated by the clinical decision making process to make a diagnosis, manage the patient and solve problems during or outside the clinical encounter. The aim is to support and augment the skills of the professional rather than substitute them as had been the trend with many of the early stand-alone paternalistic “Greek Oracle” diagnostic decision-making “expert” systems like MYCIN (Shortliffe 1976). It is now recognised that a decision-support system developed as part of a larger patient and institutional information system may facilitate a more meaningful dialogue between the clinician and computer. The clinician, who has broad skills, common sense and detailed knowledge of the patient, remains integral to the decision making and decision support process.

Shortliffe (1989) identified three overlapping types of decision support function based on tools for information management, focusing attention, and patient-specific consultation. Decision support covers the whole range of clinical activities and include:

1. Information management tools:
   - A knowledge base which may be on-line or off-line e.g. Oxford Textbook of Medicine on CD-ROM.
   - A patient health summary generator (Liaw & Chan 1993).
2. Tools to focus attention:
   - A patient recall system e.g. for PAP smears (Hogg 1990).

- A patient and/or doctor reminder or alert system e.g. flu vaccination (McDonald et al 1980).
- Structured and/or prompted data entry e.g. problem-knowledge coupler (Weed & Zimny 1989).
- Structured and/or prompted management protocols e.g. health maintenance activities (Hanh & Berger 1990) or geriatric assessment (Devore 1991).

3. Tools for patient-specific consultation:
    - A background “watch-dog” and/or critic of decisions made e.g. abdominal pain (de Dombal et al 1991).
    - A post-hoc evaluator of diagnostic and management decisions and/or tasks e.g. hypertension management (HYPERCRITIC: van der Lei 1991)
    - A *decision maker* or expert system e.g. the Quick Medical Reference (QMR: Miller et al 1986).

To facilitate meaningful and useful dialogue between the clinician and the decision support system, both must be capable of “learning” together. Like its human counterpart, a decision-support system can learn by instruction, experience or both. Learning by instruction is relatively much easier to understand, design, and write code for than experiential learning. For instance, the McGill University Family Folder Information Network (MUFFIN: Liaw & Chan 1993) allows new evidence-based information such as drug interactions or effective health promotion protocols to be taught to the decision support system. Experiential learning is usually associated with artificial neural networks, which use serial and parallel processing, connectivity and non-linear programming to model the multisynaptic, excitatory and inhibitory neuronal structure of the brain. The pattern recognition property of neural networks used to model experiential learning is still limited to very narrow decision support application areas such as mammography (Patrick et al 1991). An appreciation of learning capability is important in understanding decision support, although a detailed understanding of cognitive science, belief networks, neural networks and knowledge representation is not essential.

Components of a decision support system

The fundamental components of a decision support system are:

- A comprehensive and current knowledge base containing information based on high quality evidence.
- A decision support (or inference) engine to implement the decision rules. It may include experiential learning techniques.
- A well-structured patient database upon which the decision support rules are applied.
- Interfaces to allow ongoing mutual teaching, learning and feedback by instruction between clinician and computer as well as the updating of the various information databases.

Techniques for decision support

The techniques have traditionally been one or more of the following:

- Knowledge bases with data elements linked by relational algebra (*categorical reasoning*).

- Quantitative handling of uncertainty and probability based on Bayes theorem (*probabilistic reasoning*).
- Symbolic inference techniques as used in artificial intelligence research (*symbolic reasoning*).

Higher level techniques have been developed to address the fact that health data and health knowledge are often incomplete, inaccurate and inconsistent. They include:

- Heuristic systems, which combine categorical and/or symbolic reasoning with probabilistic reasoning e.g diagnostic systems such as RECONSIDER (Blois et al 1981), Quick Medical Reference (QMR: Miller & Masarie 1992) and ILIAD (Lau & Warner 1992). Bayesian belief networks are more mathematically complex systems which include probabilistic dependencies of symptoms and signs (Herskovits & Copper 1991). For example, the breathless patient with a family history of asthma, wheeze and productive cough is more likely to have asthma than cardiac failure.
- Diagnostic systems based on fuzzy set theory (Adlassnig 1980).

All these techniques have limited applicability to real life and clinical practice. Acceptance depends on the users' personal beliefs in computer-based modelling techniques. Most of the decision support systems that have a broad application domain tend to be rule-based with mostly categorical and probabilistic reasoning. Symbolic reasoning and applications capable of experiential learning are still limited in their scope.

The definition and organisation of the critical data elements

The traditional preference by clinicians to record text rather than data elements makes knowledge representation difficult although some effort, e.g. the Linguistic String Project, has been devoted to natural language processing (Sager et al 1993). Knowledge representation and logic engineering techniques prefer the data elements to be structured and defined at the most basic (*atomic*) conceptual level, allowing greater flexibility and combinations to build more complex concepts (*molecules*) from these simple ones (*atoms*). A nomenclature, or a list of terms/codes to describe the atoms, is essential. A taxonomy, or classification, is important to guide the construction of the molecules and give meaning to the knowledge accumulated.

The issue of which conceptual level is the most clinician-friendly and relevant to health care is being addressed with increasing discourse and research into coding, classification and knowledge representation. The most widely used coding and classification systems are the International Classification of Diseases (ICD), Systematised Nomenclature of Medicine (SNOMED: Cote & Robboy 1980), Read Codes (Read 1990), and International Classification of Primary Care (ICPC: Lamberts & Wood 1987). The ICPC is a classification system with a low level of specificity, while the ICD and SNOMED have very detailed and specific nomenclatures.

Knowledge bases

A decision support system is only as good as the quality of its knowledge base, decision rules and patient database - the information must be current, valid and reliable. The design of the decision support system must allow easy and specific updating of the decision support logic (rules and probability) when new high quality evidence becomes available. Electronic knowledge must be easily share-able and re-usable. Maintenance of the quality of the knowledge base over time is a problem in terms of the continued availability of skilled personnel, time and other resources, a general lack of high quality evidence and the lack of connectivity to allow the easy sharing of knowledge and logic modules between different decision support systems.

Structured collection of patient data

Structured data entry is an attempt to reduce the uncertainty, indecision and noise that contribute to the large variations in estimates of prevalence of health problems and utilisation of services by patients and clinicians in various health care settings and regions. At the least specific conceptual level, data collected in an encounter can be categorised into the Reason For Encounter (RFE), diagnosis (Dx) and process of care. The RFE is the outcome of a consensus between the patient’s demand for care and the clinician’s assessment of that demand. The decisions made can and should be qualified by the degree of certainty based on objective criteria e.g. diagnostic criteria. By making explicit the three main components of the encounter as sources of uncertainty, variance and error, the structured *RFE-Dx-Process* approach to data entry can limit the number of possibilities and reduce the potential for errors, leading to enhanced accuracy of data collection.

The structure of the patient database need to facilitate longitudinal, temporal and lateral linkages among the data elements. Lateral linkages concern information like blood or family relationships which must be “taught” to the computerised patient database. Automated longitudinal and temporal linkages will allow the creation and maintenance of a longitudinal record and patient summary organised into problem contacts, encounters and episodes of disease/ill-health and care. This structured patient database will enable easier, more flexible and more efficient design of the decision support engine which will allow a more varied examination of the database e.g. relating process to outcome of care, family-based or genetic analysis of the data or predicting natural history of symptoms during an episode of a health problem.

Computer-assisted data collection to enhance data quality

Computer-assisted data collection based on “problem-knowledge coupling” (Weed & Zimny 1989) can improve the quality of the data. The clinician must be critically aware of the nature and quality of the evidence for his/her diagnostic and management decisions and the conceptual and practical limitations of the decision support system involved. These broad critical skills are essential “core behaviour” to allow the best use of decision support to make diagnostic decisions, facilitate best practice in the management of health problems, and record the encounter accurately and comprehensively. This broadly-skilled clinician is the best guarantee of optimum data quality in the patient database.

A clinical framework to establish the information requirements for decision making

Coexisting physical and mental health problems, compounded with family, social or work problems present considerable diagnostic and management difficulties and uncertainty in clinical practice. The need to establish the information requirements at each clinical encounter is most acute in general/family practice which is mainly concerned with ill-defined and undifferentiated problems in an environment of many short encounters with many patients over time. The context and the degree of uncertainty may vary, but the primary focus of all clinicians is the patient and his/her reason for encounter. Loosely based on a list of consultation tasks (Pendleton et al 1984), *Figure 14.1* summarises a patient-centred clinical framework which shows the information needed for and generated by each step of the encounter and decision-making process and highlights the relevance of information and responsibility sharing. The various points in the model are amenable to decision-support. The choice of a particular type of clinical decision support depends on:

- The nature of the problem and degree of uncertainty.
- The nature of the decision and degree of indecision.
- The environment in which the decision is made.
- The character and preferences of the individual clinician.

Thus less experienced clinicians may value a diagnostic decision support more than experienced ones particularly if the medicolegal environment is highly charged as in situations of rape and criminal injury.

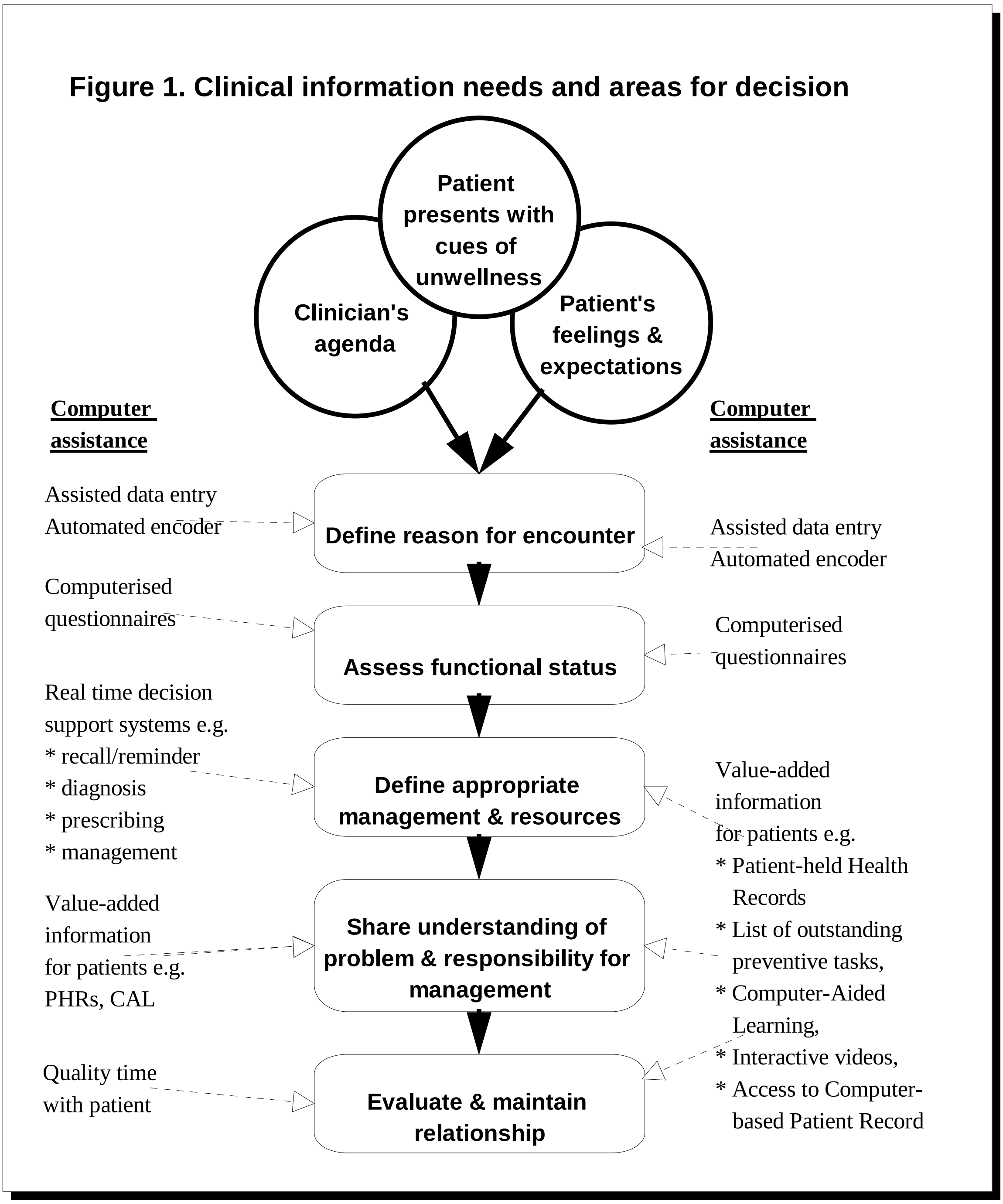

Figure 14.1 Clinical information needs and areas for decision support

Decision support systems available within this clinical framework

Defining and coding the reason(s) for encounter

Structured and computer-assisted data entry by patient and/or doctor is the main form of decision support available for these clinical tasks. These may be stand-alone packages or are part of an integrated computer-based patient record system. The problem-knowledge coupler (Weed & Zimny 1989) prompts the clinician to ask relevant questions associated with the presenting complaint. However, the choice of a particular problem-knowledge coupler, e.g. cardiovascular or psychiatric coupler, remains with the clinician.

Assessment of functional status and lifestyle factors

There are numerous automated questionnaires to assess health, functional status, diet, lifestyle factors and problems like anxiety and depression. Using data entered by the patient and/or the clinician, these systems use a simple scoring and ranking capability to generate either raw or interpreted scores which may help decision making. While these are usually stand-alone applications used in specialty areas, they can also be incorporated into a patient database as on-line decision support for patients and clinicians.

Defining the diagnosis and/or labelling the problem

Diagnostic decision support systems may take the form of:

- an on-line prompt (Weed & Zimny 1989).
- an on-line information/knowledge base e.g. a hypermedia document collection (Timpka et al 1982).
- a “watchdog” to warn of mistakes (de Dombal et al 1991).
- a “decision-maker” e.g. QMR (Miller et al 1986).

The problem-knowledge coupler (Weed & Zimny 1989) provides a list of associated symptoms and differential diagnoses as part of on-line decision support. The use of a “watchdog” computer-aided diagnosis of abdominal pain has been shown to improve the management of patients who present to emergency departments with abdominal pain (de Dombal et al 1991). The pattern recognition capabilities of artificial neural networks have been used to analyse pain drawings by patients with low back pain to recognise and classify the pain with some success (Mann & Brown 1991). “Decision-makers” are popular in the various specialty areas, where the breadth of knowledge is small but the depth of knowledge is great e.g. the diagnosis of colonic lesions has been shown to be 98% accurate (Graham et al 1990), MAGIC (*Melanoma Analysis and Graphic Imaging by Computer*: White et al 1991) which uses a set of rules to decide if a video image of a lesion was a melanoma or not, or the OUTCOME ADVISOR, a diagnostic decision support for mammography which also uses neural network concepts to learn (Patrick et al 1991). QMR attempts to give an answer to the symptoms and signs presented by the patient.

Defining appropriate management and use of resources

On-line reminders which prompts important health information e.g. drug allergies or outstanding preventive activities when the patient file is opened are simple management decision support systems (McDonald et al 1980). This information may be picked up automatically from the patient files or entered manually by the patient, clinician or office staff. Recall lists e.g. flu vaccinations or PAP smears and patient registers e.g. diabetes are other simple forms of management decision support based on time and disease (Hogg 1990).

More sophisticated decision support systems involves automated knowledge-based decision support protocols which examine the patient database and make a series of decisions on the completeness of the information. For instance, MUFFIN uses health maintenance protocols to generate a list of outstanding health promotion and disease management tasks for each patient to facilitate opportunistic health promotion and chronic disease management during the encounter. A prototype prescribing decision support system searches the patient database, highlights drug allergies and potentially adverse drug combinations, and recommends a medication for diagnoses made during the encounter. The adverse reactions probability scale (APS: Naranjo et al 1981), Yale algorithms (Kramer et al 1979) and other medication databases have been added to the QMR to provide decision support for good quality prescribing. Use of structured hypertension management protocols has been shown to improve understanding and management of compliance (ARTEMIS: Degoulet et al 1982). HYPERCRITIC, which allows a clinician to reflect on his/her decisions after the encounter, has also been shown to improve the management of hypertension (van der Lei 1991). DIACON, a microcomputer-based decision support system for diabetes, provides: (i) information management including statistical analysis of patient and laboratory data, diagnosis of diabetic keto-acidosis, advice to patients on insulin dose based on glucose readings, therapeutic education programs and computer-assisted implanted pump devices; (ii) computer aids including memory glucose reflectance meters and an insulin dosage computer, and (iii) educational programs on computer (Laron et al 1989).

Information and responsibility sharing

A shared understanding and the involvement of patients in the management of their health problems is an axiom of clinical care. A computer-generated patient summary, which contains personal health information, outstanding health promotion tasks and general health education information, given to patients to keep and use can act as a patient and clinician reminder, achieve this shared understanding, and increase patients' responsibility for their own health care (Liaw 1993). A dilemma in information sharing is that while information theory reassures us that messages can be transmitted reliably, physical laws and probability tell us that these messages tend to become garbled easily. Ley et al (1976) emphasised that patient satisfaction and compliance depend on accurate, unambiguous, relevant and simple messages and measures to improve comprehension and recall. Computer-generated patient-held health records (PHR) summarise and present patient information consistently and legibly to facilitate information and responsibility sharing. Patient access to on-line personal health information via a modem has also been shown to be practical and feasible (Jones et al 1992)

Evaluating and maintaining the relationship

Computer assistance in diagnostic and management decisions, which also facilitate the sharing of information and responsibility, can improve the quality and efficiency of the clinical encounter and promote a comprehensive approach to health care by patients and clinicians. More time is made available to establish, evaluate and maintain an effective long term patient-clinician relationship.

Some issues with decision support

A recent overview of trials of clinical decision support systems suggests that they can improve clinician performance (Johnston et al 1994). However, there are also problematic issues such as unproven effectiveness, high costs, potential adverse effect on the patient-doctor relationship, legal accountability for mishaps, implementation problems including lack of use of computer-based patient records, lack of inter-operability between different operating systems, and indifferent or antagonistic attitudes of clinicians remain. The legal aspect of decision support depends on whether the courts view decision support under negligence (medical malpractice) law or product liability law or both. Consider DIACON: the information management module may raise issues relevant to negligence law while the computer-assisted implanted pump device module will be viewed as a medical device. On the other side of the coin, are clinicians liable for malpractice if they chose not to consult a decision support system?

The philosophical question of control of knowledge and behaviour must also be appreciated. Opinions differ on how computer assistance in clinical practice should be taught and used. At one end of the spectrum, Weed (1990) advocates a paradigm change from teaching a “core of knowledge” to teaching a “core of computer-based behaviour”. Others, more wary of the enormity of the task in effecting behaviour change, advocate the use of computers to facilitate the teaching and maintenance of this “core of knowledge”. This less radical approach appear to be the majority view as reflected by the relative abundance of applications employing techniques such as natural language processing, temporal and spatial reasoning to try to make sense of data collected by clinicians trained under this “core of knowledge” paradigm. The differences in opinion remain although the literature and recent developments in the American Medical Informatics scene suggest that these views are becoming less polarised.

The next steps

Because only a minority of clinicians use computer-based patient records to any extent, the strategy to define and facilitate the use of decision support systems must include:

- Appreciation of the decision support needs of clinicians.
- Consensus on the appropriate technique(s) of decision support to improve quality of care.
- The development of practical systems that can learn from and teach clinicians.
- Modular approaches to design to encourage clinicians with varying levels of computer literacy to use decision support.
- Rigorous evaluation of the accuracy, consistency, adaptability, learning capability and usefulness of such systems.

Evaluation must examine if a decision support system models an expert’s activity and knowledge adequately and appropriately i.e. *is it practical, useful, open to ideas (i.e. can learn), and able to teach*? The main problem with evaluation is a lack of acceptable and valid “gold standards” in clinical decision-making or, often, the decision itself. Some of the standards used have been a clinical expert or a cluster analysis of the decisions of a panel of clinical experts. The extent of utilisation of a system is an indicator of its usefulness: clinicians will only use decision support if it is useful. Other evaluation questions must address the impact of decision support on health care, health costs and health.

Conclusion

The potential for decision support systems in clinical practice remains great. Computer-based modelling must be used in conjunction with well-established knowledge bases and decision rules within the context of well-structured patient information. The broadly skilled clinician with intimate knowledge of the patient is central to the decision-support and decision-making process. The evolution *from* the paternalistic “Greek Oracle” model, which substitute professional decisions, *to* the collaborative model of decision support, which facilitate professional and clinical decision-making, suggests that we are heading in the right direction.

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