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The Computer as Clinical Consultant.
Edward H. Shortliffe,
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Editorials

The Computer as Clinical Consultant

Although computing technology is playing an increasingly important role in medicine, systems designed to advise physicians on diagnosis or therapy selection have received poor clinical acceptance. Despite diverse research efforts, and a literature on computer-aided diagnosis that has numbered at least 1,000 references in the last 20 years, clinical consultation programs have seldom been used other than in experimental environments.

The reasons for attempting to develop such systems are self-evident. Growth in medical knowledge has far surpassed the ability of the single practitioner to master it all, and the computer's superior information processing capacity thereby offers a natural appeal. Furthermore, the reasoning processes of medical experts are poorly understood; attempts to model expert decision making necessarily require a degree of introspection and a structured experimentation that may, in turn, improve the quality of the physician's own clinical decisions, making them more reproducible and defensible. New insights that result may also allow us more adequately to teach medical students and house staff the techniques for reaching good decisions, rather than merely to offer a collection of facts that they must independently learn to use coherently.

In recent years observers have begun to analyze the reasons for poor acceptance of the systems that have sprung from such research.[1] My colleagues and I have recently argued[2] that the problems have tended to lie not only with the decision-making performance of such programs, but also with system design features that have failed to appreciate the physician's viewpoint or have made the interactive process unappealing. To correct these deficiencies, future systems must be fast, easy to use, and congenial. They must address important clinical problems with which physicians recognize that they need assistance. But perhaps most important, to stress the primary physician's role as ultimate decision maker, they must be able to explain what they are doing, not through quotations of statistical theory but in terms of a line of reasoning that is familiar and similar to the kind of justification a clinician might expect from a human consultant. Explanation capabilities help the physician using the program decide whether to follow its advice; they thereby emphasize the computer's function as a helpful tool that is intended to complement, rather than replace, the primary physician's own decision-making powers.

Because of considerations such as these, the last decade has witnessed the development of new approaches to computer-based medical decision making. Of particular importance is research directed at the encoding and utilization of experts' judgmental knowledge—the kind of practical experience that underlies the daily practice of medicine and is far removed from the mathematical approaches of formal decision analysis. One relevant computer science subfield, termed "artificial intelligence" because of its emphasis on symbolic reasoning capabilities rather than numeric computations, has recently formed the theoretic foundation of several experimental consultation programs.[3] Our own is the MYCIN system, a program that assists with the selection of antimicrobial therapy for patients with infections.[4] Knowledge of bacteremia and meningitis has been acquired from infectious disease experts and encoded in decision "rules" and tables of simple facts (such as normal antibiotic resistance patterns). This knowledge is, in turn, used by a program that considers a specific case, interacting with the physician requesting advice and generating a therapeutic recommendation. By responding to specific questions asked by the physician and translating computer code into understandable English, MYCIN is also able to explain the basis for its decisions so that the user can independently decide whether to follow its advice. Although the program's knowledge base is still being expanded, and its theoretical underpinnings are undergoing revisions as new performance problems are identified, MYCIN has been demonstrated to function similarly to infectious disease experts when selecting therapy for isolated bacteremias[5] or meningitis.[6] Demonstration of its acceptability to physicians awaits its clinical implementation after the knowledge has been broadened to include other infectious diseases.

This kind of promising research into medical symbolic reasoning represents more than the application of well-established computing techniques. The approaches are young and experimental, and they demand refinement. Extensive basic medical computing investigation will be required, in artificial intelligence and in related computer science subfields, before useful, congenial, high-performance consultation systems will be available and accepted by physicians. For example, successful systems are unlikely until we know better how to manage such problems as (1) understanding the psychology of medical reasoning as practiced by specialists, (2) automated interpretation of written and spoken natural language, (3) the acquisition and representation of knowledge obtained from collaborating experts, (4) the encoding and use of time relationships central to many disease processes, and (5) mechanisms for representing and measuring inexact reasoning. The potential of such research is great, but progress may depend in part on increased recognition that computer science represents an important form of basic medical investigation.

EDWARD H. SHORTLIFFE, MD, PHD
Stanford University Medical Center
School of Medicine
Stanford, CA 94305

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