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The Tacit Dimension of Clinical Judgment

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Two distinct views of the nature of clinical judgment are identified and contrasted. The dominant view that clinical judgment is a fully explicit process is compared to the relatively neglected view that tacit knowledge plays a substantial role in the clinician's mental operations. The tacit dimension of medical thinking is explored at length. The discussion suggests severe limits when applying decision analysis, expert systems, and computer-aided cost-benefit review to medicine. The goals and practices of postgraduate medical education are also examined from this perspective, as are various other implications for the clinician. The paper concludes that it is valuable to explore the nature of medical thinking in order to improve clinical practice and education. Such explorations should, however, take cognizance of the often overlooked tacit dimension of clinical judgment. Possible constraints on the medical applicability of both formal expert systems and heavily didactic instructional programs are considered.

Today's clinician confronts a rapidly changing health care industry. In the future he will be making clinical judgments within a more structured context, in greater accordance with guidelines and policies determined by professional health care managers. With medical expenses now accounting for more than 11 percent of the gross national product, up from 6 percent in 1965 [1], medical policy makers will increasingly rely upon computer-aided decision theory and cost-management systems when determining the conditions and efficacy of clinical practice. Such policies will necessarily alter the context in which clinical judgments are made. It is thus important to ask whether the practice of clinical judgment will be aided or hindered by the development of more structured guidelines and computer-aided supervision and review of the practitioner.

It therefore becomes important to consider the nature of clinical judgment, to know the conditions under which its practice will prosper or suffer. This paper is a step in that direction, although its subject is limited to only one aspect of the cognitive nature of the clinician's knowledge. It attempts to demonstrate that health care policy is being shaped in accordance with a specific view of the nature of this knowledge, a view which could be said to perceive no difference in principle between the clinician's thought processes and those of a sophisticated computer software program. At minimum, this view holds that intuitive clinical judgment can be equalled or outperformed by decision analysis in many complex circumstances. This view of clinical judgment contrasts with an alternative view, one which takes account of a separate tacit dimension of clinical judgment. This tacit dimension contains knowledge which could never be reduced to a software program; consequently, it defines certain limits for the efficacy of computerized medical decision making and review. The distinction between these two views of clinical judgment must be analyzed if we are to develop a useful knowledge of the

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conditions required for successful clinical judgment and practice. The implications of this analysis for health care policy making, medical education, and clinical practice will become apparent as the discussion proceeds.

Before turning to an analysis of these two views, let us briefly define the scope of clinical judgment as it is discussed herein. For the current purpose, clinical judgment refers to the totality of the mental processes involved in all stages at which the clinician collects and interprets data; formulates a problem statement, confirms and refutes diagnostic hypotheses; considers, plans, and implements possible diagnostic and therapeutic options, tests, and interventions; and evaluates likelihoods and outcomes. It is often convenient to divide clinical judgment into several components; e.g., hypothesis generation and evaluation; diagnostic and therapeutic outcome probability assessment; and therapeutic strategy decision making. For the context of this discussion, no distinction is drawn between the various stages and aspects of the clinician's enterprise.

Having outlined the territory to be explored under the concept of clinical judgment, let us begin by clearly distinguishing the two contrasting views of knowledge used in such judgment and decision making. The dominant view among physicians and educators, which is basically the only view acknowledged by professional policy makers and cost analysts, is one that characterizes clinical judgment as a fully explicit process, involving in all respects the conscious application of defined rules and knowledge. It contrasts with the neglected view that tacit, or implicit, knowledge plays a substantial role in clinical judgment. The neglected view, while not formally acknowledged by many practicing clinicians, is, in fact, partly the basis for their increasing unease over the growing role played in clinical medicine by the equations and computerized programs of the policy makers and health care managers. In the discussion that follows, the meaning and consequences for practice of each view will be discussed. The primary intention is to elucidate the neglected tacit dimension of clinical judgment and emphasize certain significant aspects of this dimension for clinical practice, health care policy, and medical education.

The first view, that medicine has a defined knowledge base which can be known, communicated, and clinically applied in an entirely explicit, or overt, fashion is the view that seems intuitively obvious to many observers. It is also the dominant theory among scholars who analyze such professional activity as medicine [2,3] and is uniformly accepted by health care software systems analysts and policy makers. In essence, it holds that ideal clinical judgment consists exclusively of consciously applying explicit knowledge to the patient's problem.

On this view, the body of medical knowledge is a mixture of explicitly known observations, principles, and rules. This belief does not mean that medicine is a purely scientific endeavor. On the contrary, within this body of overt knowledge one can discern two general categories, scientific and practical knowledge. The former category comprises that medical knowledge which has been validated by scientific research. An example is the knowledge obtained by applying the results of a prospective study contrasting a given intervention with an alternative and concluding that one course is associated with a favorable outcome. Scientific knowledge continues to increase in medicine as clinical and basic research progresses.

The second category of explicit medical knowledge is practical knowledge—that is, knowledge which has been established by prior clinical expertise [4] and empirically thought to be useful, but which has not yet been subjected to rigorous scientific analysis for confirmation or refutation. At present, medicine remains heavily reliant upon such

practical knowledge because, as a young science undergoing transformation, its knowledge base is still not fully systematized and standardized [5]. As medicine matures, however, its scientific component will expand while the practical shrinks. As the scientific realm enlarges by means of basic and clinical investigations, it will encroach upon the diminishing domain of practical knowledge by allowing the physician to confirm or refute such knowledge experimentally. Ultimately the mixture of practical and scientific knowledge upon which the clinician currently depends may be replaced by a systematic body of scientifically validated facts and rules.

Thus, the explicit view does not hold that medicine is a pure science. It fully acknowledges that medical knowledge comprises two components, the scientific and the practical. On this view, however, the components differ solely by the extent to which the knowledge has been subjected to scientific validation. Both types of knowledge are similar in that they are explicitly known by the clinician. They can both be consciously applied in practice, conveyed and acquired during instruction, and both are well itemized and described in the medical literature [6,7]. True, practical knowledge lacks the important advantage of scientific validation, but its ultimate confirmation or refutation is basically a matter of time. The essential point of this view is that all medical knowledge, whether scientific or practical, comprises a body of fully explicit knowledge.

The important consequence of this view is that if the clinician possesses such an exclusively explicit body of medical knowledge, then clinical judgment can be seen as a task of problem solving whereby the clinician consciously identifies his diagnostic and therapeutic options by applying explicitly known clinical facts and rules to the specific case at hand. Of course, such application is not always a simple process, especially when the complexity and uncertainty involved in the specific case are great. One of the important consequences of this view, however, is that, in particularly complex cases, the clinician can make productive use of such formal quantitative models as decision analysis. The premise underlying the use of formal models is that, given adequate data and computing capability, it is possible to build a prescriptive system capable of complex clinical decision making [8,9]. This task is achieved by separating the components of the decision problem, analyzing and quantifying them individually, and then recombining them systematically to make the optimal decision. Since no clinician can intuitively consider all the important factors in a complex clinical decision [10], a formal system which can explicitly identify and quantify all relevant data, options, and outcomes is thought to have a greater potential ability than intuition for dealing with complexity and uncertainty.

In summary, on this view, explicit thought processes fully constitute and explain clinical judgment. A corollary point is that formal models can introduce additional systematization into these overt processes and thereby mimic, improve, and extend clinical judgment. Optimal clinical decision making then depends upon exactly identifying, quantifying, and integrating all relevant data, options, and outcomes [11]. Obviously then, to the extent that these relevant variables can be overtly identified and quantified, the clinician will be successful. On the other hand, to the extent that the clinician fails to make explicit key information, he cannot adequately use such knowledge and may overlook the optimal decision. The presumed advantage of formal models is precisely their ability to enhance the clinician's likelihood of success by providing him increased precision and organization [12]. As we shall see, these formal models hold special attraction for health care policy makers.

Without question, the explicit theory is a widely held view of the nature of professional judgment, especially clinical judgment. At first glance, it appears intuitively obvious. It is clearly the view described in most scholarly discussions of the subject [2,3] and the basis for much teaching in the clinical setting [13,14]. It also provides much of the theoretical base upon which is built the impressive edifice of decision analysis, artificial intelligence expert systems, and applications for clinical prediction rules, algorithms, and judgment theory. The explicit view holds that precise policies can be devised with the capability of designating universal rules to govern individual medical cases. Thus, this view provides the foundation for the decision theory approach to medicine of the cost-management systems which are currently proliferating in number and influence among policy analysts. It is also influencing medical and postgraduate education and training. We shall return to these points. Before we do so, it becomes essential to ask whether the explicit view actually provides a complete and satisfactory explanation of the clinical judgment process.

Let us now look at the dissenting opinion, the theory of tacit knowledge [15,16], or of professional judgment as knowing-in-action [6]. On this second view, it is an error to expect or assist the clinician to make fully explicit and quantifiable the entire range of data and rules he uses in clinical judgment. Much of the knowledge he uses is not explicit, could not be made explicit, and does not need to be.

To understand this second view, we must initially ask: What is knowledge that is not explicit? At first glance, this question seems a contradiction: to know something would seen to include the ability explicitly to identify and communicate its essence. Not necessarily. On this alternative view, there is also tacit knowledge, i.e., knowledge which is possessed and utilized on an implicit, or subsidiary, level without conscious awareness. In extensive discussions, Michael Polanyi [17] argues that clinicians possess both explicit knowledge, of which the content and use are subject to focal conscious awareness, and tacit knowledge, which is not explicitly experienced. In fact, he argues, there is a tacit component to all knowledge, including explicit knowledge. Although we make many decisions at an explicit level, a wholly explicit system of knowledge is impossible. Tacit integrations underlie our conscious deliberations; their speed and complexity permit our explicit operations to function. We have all experienced an intuitive insight allowing us to arrive at an unaccountable conclusion in a flash. Polanyi would attribute the rapidity of this process to tacit integrations which underlie and facilitate conscious reasoning.

We shall elucidate the theory of tacit knowledge in much greater detail. At this point it may be appropriate to pause for a critical observation. In modern professional education, there is a dominant epistemological tradition, i.e., dominant theory of how professionals think and know. This tradition strongly emphasizes an exclusive role for explicit knowledge in such enterprises, and relegates tacit knowledge to the realm of non-professional, irrational, or even mystical thought. Thus, clinicians and medical policy makers educated within this widely accepted tradition are likely to find the components of the theory of tacit knowledge unfamiliar. Measured against the standards of explicit thought, these concepts initially appear vague, nonspecific, or confused. In anticipation of this possibility, I offer in defense the promise that the concepts will become clearer as the discussion proceeds. Initially, according to the reader's personal introspection, he or she may vary in affinity for the theory. The value of seriously considering this unfamiliar alternative view of clinical judgment lies in the

implications of the theory for clinical practice, medical education, and health care policy making, as we shall see.

It is important to recognize that this view is not simply an argument that expert clinicians make decisions and take actions more rapidly than do students and residents because they can shorten the time needed consciously to analyze and make decisions in complex situations. Nor is it simply an argument that medical knowledge comprises the two previously discussed categories of consciously used knowledge, scientific and practical. Both such arguments are undoubtedly true; however, the theory of tacit knowledge argues something quite different; i.e., that, in addition to explicit knowledge, clinicians also possess and utilize implicit, or tacit, awareness of a vast and indeterminate range of data, amounting to actual knowledge that cannot be explicitly stated. Let us explore further the complex nature of tacit knowledge.

Tacit knowledge cannot be articulated in explicit terms. It is the "knowing how" which the clinician partners with the "knowing what" of his explicit information. That is, it is the implicit knowledge which tells him how to use his explicitly known facts and rules. As such, tacit knowledge is involved in the acquisition and use of physical skills, mental abilities, and those processes which combine both. First we shall consider several examples of basic skills that illustrate the role of the tacit dimension. Then we will carry the discussion over to the domain of complex mental abilities such as clinical judgment.

A simple example of tacit knowledge is the knowledge of how to ride a bicycle. Bicycle riding is a skill requiring complex knowledge of multiple interrelated muscular movements. That knowledge, once possessed, is used almost effortlessly; however, it is beyond the conscious awareness of the user. That is, it is not possible for the rider to specify or to be focally aware of all the muscle group interactions involved in the process, even as he rides the bicycle. To the extent that such unspecifiable knowledge is used, the skill of bicycle riding is as much an art of doing as it is an art of knowing [18]. In other words, this inarticulable knowledge is contained and expressed in actions rather than conscious thoughts.

Consider next the example of the knowledge used to recognize one special human face in a crowd. It is difficult, if not impossible, to itemize and describe fully all the cues and variables which are identified and integrated during the common process of not only distinguishing one human face from all others, but also recognizing the mood or attitude communicated via that human face. Nevertheless, although such knowledge cannot be expressed in explicit terms, it can be well known and used on a tacit level. Indeed, the experienced pediatrician relies on similar knowledge to distinguish the face of the toxic infant from that of the merely irritated or tired child.

Another example of the tacit dimension is the surgeon's knowledge of the precise amount of tension to exert upon the suture. This perception is not information he possesses and communicates in explicit terms. Rather, it is knowledge he feels and shows during the practice of the skill. In fact, consider the example of the surgeon's ability to operate by using various instruments as though they are extensions of his own hand. The tacit knowledge of how to use and feel through a tool, and of how to know the spatial position of the tip of the instrument as if it were one's own fingertip, is well known to many artisans and craftsmen, as well as surgeons, but cannot be articulated in explicit terms.

Perhaps an even better example to clarify the difference between tacit and explicit knowledge can be borrowed from the field of music. Consider the expert pianist who

can perform brillantly, but freezes in mid-concert if he begins to concentrate on the movement of his fingers instead of the music. This experience can occur because piano playing is a complex skill, involving many essential tacit and explicit components which are integrated by tacitly held knowledge. During practice, the pianist acquired some of this tacit knowledge in an explicit fashion; however, after he integrated it into his tacit awareness he began to possess and use it without conscious reflection. Indeed, his attempt during the performance to focus consciously on this tacitly held knowledge is not only unsuccessful, it can disrupt his skillful performance. This example demonstrates the important claim that tacit knowledge, once acquired, can be used and acknowledged, but it cannot necessarily be identified or analyzed.

Bicycle riding, recognizing a face and its mood, using surgical instruments, and piano playing are all examples of skills and abilities that appear to rely strongly upon tacit knowledge. That is, one cannot consciously identify all the routines and knowledge employed when using these skills. In fact, as we shall discuss further, there is actual knowledge contained in the possession and use of such skills, knowledge which cannot be specified or articulated on an explicit level.

The theory as expressed thus far may impress the reader as more applicable to physical skills and abilities, such as surgical techniques and methods of physical examination. Perhaps the reader can introspectively identify many other familiar physical skills which are practiced by using tacit routines without focal awareness. Oakeshott [19], however, argues that the use of tacit knowledge is not limited to the practice of skills and abilities which involve physical doing or making; rather, it is equally important to skills composed of mental operations, such as clinical judgment. On this view, the knowledge employed in any skill, physical or mental, can be divided into two partnered components: explicit and tacit. The use of the explicit component of knowledge, the "knowing what," actually depends upon the underlying tacit component, the "knowing how." Let us look at these two components in the context of clinical judgment.

First, consider the explicit component. In the context of clinical judgment, the explicit component is all the information the clinician can acquire, i.e., the explicit knowledge whereby what he knows may be defined, itemized, and conveyed by instruction. It includes facts, rules, and propositions, mostly accepted on authority, and is found in the articles, manuals, and textbooks of the medical literature. It includes our knowledge of the diagnostic signs and symptoms, the therapeutic options, the possible outcomes, the various probabilities involved, and so on. This is the knowledge used to construct decision trees and clinical rules. This is the explicit medical information which is used to provide the appropriate answer to questions which ask: what? where? when? which? how long? how much? how likely? and the like [19]. Such explicit information is an ingredient of all medical knowledge. It ranges from vague identifications to formal propositions and rules. It is the totality of the information used by the software systems experts. But this explicit information never constitutes the whole of what the clinician knows. The complementary component of the partnership of knowledge is the tacit dimension.

The tacit dimension of clinical expertise is the implicit knowledge which constitutes the "knowing how," which the clinician partners with the "knowing what" of his explicit information. It is this component, unspecifiable in propositions, which cannot be resolved into explicit information, but which enables the clinician to use such information.

This is the knowledge required to interpret and decide the relevance of explicit information, and used to recognize and apply the appropriate explicit rules to a given problem. For example, it is the knowledge which goes beyond the physical findings, lab data, and clinical rules when the intensivist fine tunes the controls of a mechanical ventilator. It is all that knowledge which integrates and permits the choice and use of the appropriate explicit rules and methods. It is the knowledge excluded from decision trees and software systems. Indeed, without tacit judgment, isolated explicit information may or may not be useful. Isolated, the greatest value of explicit information to the clinician may be when he takes an examination or presents a case discussion. In his daily practice, such information is not isolated, but is united with tacit knowledge, enabling the clinician to recognize the applicable clinical rules and integrate the appropriate data.

Consider as an example the expert radiologist [20], who can sort through a range of vague shadows and shapes and find concealed therein a panorama of significant details. Although explicit data and rules greatly inform his task, it is tacit judgment which unites with that information to generate his diagnostic skill. Indeed, the complex task of the radiology resident, requiring four years of apprenticeship, is not simply to retire to the library and memorize volumes of images and the rules for their interpretation. That might be relatively easy; however, the task is to also master the tacit routines which complement the explicit rules of the practice, which tell him which rules to employ when, and which case requires the use of which information.

In order to clarify further the distinction between the two dimensions of knowledge, tacit and explicit, let us contrast them in terms of how they are taught to students. On the one hand, the teacher deliberately communicates explicit information to the student by instruction, which consists of conveying specific, impersonal, hard, isolated facts and rules. Lectures and reading assignments are liberally employed to convey this material. Such informing, or instructing, is a form of communication which contrasts with a much subtler process, whereby the teacher imparts, or implants, the tacit knowledge of how to identify and use the relevant explicit information. This tacit component must be united with the explicit component to generate knowledge or ability. It cannot be taught separately or overtly, but it may be implanted in everything that is taught. It is best shared via case presentations, rounds, and demonstrations. Thus, on this view, learning is a twofold activity composed of both acquiring explicit information and coming to possess the tacit ability to use that information [19].

A familiar phenomenon is the expert clinician who can teach best by demonstrating his problem-solving skill, but is less adept when attempting to offer a convincing reconstruction of the mental steps in the process. Such reconstructions are often naive and unsatisfying when offered to explain cases of complex clinical judgment, seeming to fail to account for key elements of the mental process [21]. One is tempted to attribute the clinician's reliance on demonstration over explanation to a personal failure of introspection, that is, to a personal inability to describe the conscious clinical rules comprising his practice. One may suggest the clinical or teaching skills of such a physician are in some way inadequate; i.e., that he simply cannot remember, reconstruct, and communicate the explicit pattern of his thinking. After all, the argument goes, it seems reasonable to expect that the clinician's conscious knowledge, whether scientific evidence or practical clinical expertise, should be explicitly known and communicable by that clinician. Nevertheless, the common occurrence of this phenom-

enon in even the acknowledged best and brightest practitioners casts doubt on that tempting explanation [21,22].

The theory of tacit knowledge provides a different explanation. It argues that the clinician-teacher has not failed introspectively to reconstruct and describe the explicit knowledge and rules he uses. On the contrary, he teaches the explicit information well. The problem is that he is describing only the explicit knowledge and rules, and omitting the complementary component of his knowledge, the tacit component. The tacit component cannot be described because the clinician is not, by definition, aware of how he uses it. When he practices his skill, however, his success involves the union of his tacitly held routines and practices with his explicitly known facts and rules.

Thus, in such an instance, the clinician's explanation of his mental process is unsatisfying precisely because it omits this key tacit component. The more complex the problem and the more experienced the clinician, the greater may be his reliance upon a union of tacit and explicit knowledge. This factor increases the possibility that his explication of the process will be less satisfying and accurate, relying, as it necessarily must, solely upon the explicit rules and information used. When the matter is understood in this light, it is realized that some instances of inadequate explanation are due to the expert clinician's failure to describe fully these tacitly held routines. In such cases, this failure does not diminish his ability and should not be construed as a deficiency of knowledge, practice, or teaching. Rather, it must be understood that when he provides his students formal instruction in the explicit rules and information to be used, he conveys only one component of the knowledge used. The complementary task in teaching clinical judgment involves imparting the tacit judgments that need to be united with that explicit information in order to generate knowledge or skill [19]. On this view, the importance and difficulty of imparting tacit knowledge has significance for medical education and postgraduate training programs, as we shall later consider.

In summary, the theory of tacit knowledge argues that skillful clinical judgment relies on more than explicit knowledge of clinical rules; the skill also makes use of tacitly held knowledge. It thus leads to the conclusion that our knowledge of medicine contains a vast range of unspecifiable elements; e.g., relationships and correlations that are not precisely definable, which we integrate by tacit mechanisms. If so, then medicine will consequently always remain, in principle, a descriptive science relying heavily upon trained perception, immeasurably rich in things that we know but cannot tell [23]. If so, in principle, no amount of scientific validation of practical clinical expertise, no degree of systematization of clinical rules into formal systems, no enhancement of our ability to achieve precise measurement and quantification of probabilities, however important all these achievements will surely be, can eliminate the permanent and important role of tacit knowledge in clinical judgment.

This theory that successful clinical judgments are made, in part, by observing a set of tacit maxims or routines which are not fully known to the clinician means that, although the explicit rules of clinical practice are useful, they do not wholly determine the practice. They can serve as a guide only if they can be integrated into the clinician's tacit knowledge. They cannot replace this knowledge. For example, the expert pediatrician who, taking telephone consultations, consistently recognizes the rare pediatric emergency among the continuous stream of benign problems relies on more than the explicit rules of pediatric practice. Of course, the greater explicit knowledge and abilities of the expert pediatrician are important in this context. But, if we deny the separate and distinct role of tacit knowledge in such tasks, we may refuse to accept the

feasibility of something alleged to have been done or observed because we cannot understand it in terms of our conscious framework. By doing so, we may explain away genuine routines or experiences which are essential to clinical practice.

The theory of tacit knowledge is repugnant to those clinicians who see only a role for explicit knowledge in their practice. They are uneasy with the thought that clinical judgments may rely in principle on tacitly held knowledge which is not and cannot be made explicit by the clinician [10,12]. They reject the view that an important dimension of clinical judgment must remain unaffected by increasingly sophisticated manipulation and quantification of explicit data and rules. On the other hand, proponents of the tacit theory are equally dismayed by the contention of the opposing view, that before the clinician can make an optimal judgment he must try as much as possible to account for and quantify every aspect of the problem, including all the available information sources, options, outcomes, and potential events [24]. They claim that the requirement for quantification and systematic exploration of all relevant data is too cumbersome to be applicable to the complexities of the clinical situation [25]. On this view, full quantification may even be an unachievable goal, because it demands a greater role for explicit knowledge than is required or possible in clinical judgment [26,27,28]. Shortly, we shall see how these opposing contentions come into open conflict over the efficacy of the formal systems used by cost-management analysts.

At first glance, this debate appears to be one more recasting of the age-old, recurring controversy over whether clinical practice is predominantly art or science [5,22,29]; however, that may not be the most salient characterization of the issues involved. Actually, the art versus science controversy most commonly focuses on the relationship between practical knowledge (art) and scientific knowledge in clinical judgment. The debate is usually over the proportions, relative significance, and interdependence of the two components. As such, its major focus is on the extent and desirability of systematization of medical knowledge. It is often accepted by both sides, however, that clinical judgment is a wholly explicit process, blending explicit practical knowledge with explicit scientific knowledge.

The present discussion focuses on a distinctly separate pair of alternatives. Specifically, this choice is over whether clinical judgment involves a wholly explicit system of rules and methods which can be identified, systematized, taught, and reviewed; or, on the other hand, whether it is also dependent upon tacit knowledge which cannot be overtly defined, even by the clinician as he uses it. The significance of whether there is an important tacit dimension in clinical judgment is the possible relevance of that dimension to actual practice, to medical education, and to health care policy making. Thus, let us now consider some specific implications of this view.

From the perspective of clinical practice, one of the foremost conclusions of the theory of tacit knowledge is that some essential knowledge inheres in the clinician's skill; thus, his practice of this skill is as much an art of doing as an art of knowing [30]. In other words, like riding a bicycle or playing a piano, clinical practice involves a tacitly held set of routines, the knowing of which are implicit in the clinician's actions. In fact, much of the knowledge he uses is actually contained and expressed through his actions, not his conscious thoughts. He does not always reflect on his use of such knowledge until during or after the action, and not always even then. In concrete terms, this means the clinician may achieve diagnostic closure and decide upon a management course without knowing every routine used in that mental process.

Subsequently, when searching for a rationale for his diagnosis or decision, he may introspectively reconsider the process in more explicit detail. As discussed above, although a rationale can usually be found, it will not necessarily reflect the tacit knowledge inherent in the decision-making process. The clinician may not be aware of that knowledge. In fact, he may be fully unaware of ever coming to possess certain knowledge in his skills; he may simply find himself using the knowledge by practicing the skill. This concept has been termed knowing-in-action [6,7].

An important application of this view concerns the utility of decision analysis or related artificial intelligence expert systems. Such approaches develop comprehensive systems of explicit rules which quantify and integrate data, options, and outcomes to prescribe optimal decisions. In principle, such systems are self-sufficient; that is, they can replace clinical intuition in a variety of clinical settings [31,32]. They are considered potentially useful for dealing with complex clinical choices [9,10] because they force the clinician to consider explicitly all the options and consequences in a given case. These systems are currently receiving much attention from those charged with developing guidelines and policies for administering health care. Cost-management companies are rapidly expanding from their previously limited role of judging the need for second opinions pre-operatively and overnight hospital stays post-operatively. They now provide extensive consultation to third-party payors on many aspects of medical expenditures and clinical practice. They do so by employing increasingly sophisticated software systems which use formal decision models to scrutinize and influence more and more details of clinical judgment [1]. Adherence to the standards of practice dictated by such explicit models is becoming less an option and more an obligation of the practicing clinician.

These formal prescriptive theories such as decision analysis require that all relevant data and options be explicitly recognized and processed so that the problem can be structured properly. This requirement means the user must identify and itemize all potential data, actions, options, and outcomes in an overt and quantitative fashion [11,32]. Clearly, these self-sufficient systems are more attractive to those who see a larger or even an exclusive role for explicit knowledge and judgment in clinical medicine. To them, the requirement that the decision problem be fully structured in an overt fashion appears a logical extension of optimal intuitive reasoning, carrying the process a step further toward ideal formalization [24,33]. On these terms, the structuring of a decision tree has the advantage of stimulating a more complete problem formulation and of forcing the clinician to recognize various hidden relationships [12]. Since clinical judgment is a fully explicit process, any attempt to increase precision and quantification can only be beneficial.

On the other hand, as discussed above, dissenters have raised concerns that the fundamental obstacle to the success of formal models may be the extent to which such thorough identification and processing of information is possible [11,25–28]. Indeed, essential information is often unavailable, as is true of various test sensitivities and specificities required to perform decision analysis [25]. The clinician may not have access to the data necessary for these models. More important, as we have seen, there may be tacit knowledge which is simply unknowable by the formal model. That is, these models must ignore knowing-in-action, that tacit portion of the clinician's knowledge which is only known through actual practice and action. If there is significant tacit knowledge which the clinician uses but cannot and does not explicitly identify, then it will not be contained within the structure of the formal system. If so, the use of formal models may require not only more explicit knowledge than is actually

used, accessible, or required by the clinician; it may require knowledge that is unspecifiable in principle. Full structuring and application of such models may not be merely cumbersome; it may be impossible.

Cognitive psychologists have identified various inconsistencies between decision outcomes predicted by explicit decision theory and those achieved by intuitive clinical decision making. Studies have clearly shown that the clinician does not always reach the conclusions one would predict by assuming his adherence to rational decision theory. These findings have been used to suggest that unaided intuition is inferior to formal systems at complex decision making. The other possibility, however, is that formal decision theory fails because it lacks certain essential knowledge possessed by the clinician in actual practice.

For example, as an explanation of the clinician's failure to adhere consistently to principles of rational decision theory, Beach and Mitchell [34] developed the contingency model which notes that such decision behavior can be seen as perfectly rational providing the costs of being rational are taken into account. The point of their argument is that clinical judgment strategies differ with respect to both the cognitive effort they require, and the probability that they will lead to an optimal solution. Consequently, physician strategy selection must be understood as contingent upon a cost-benefit compromise he makes between the level of accuracy desired and the appropriate investment of time, money, and effort. The outcome of this compromise may violate decision theory, but it is often a rational decision based on tacit knowledge lacking in the formal system against which his judgment is measured. Thus, the decision theory, not the clinician, may be in error when discrepancies arise.

Similarly, Thorngate [35] noted that on occasion clinicians appear to violate probabilistic reasoning principles predicted by formal theories. He suggests the reason is that, in certain contexts, clinicians may not notice or care about small or infrequent decrements in reward, which may result from their ignorance or misuse of probabilistic reasoning. Often, they may not use such information because the time or effort required to use it properly may be more costly than any decrease in payoffs associated with their occasional suboptimal choices. Thus, the clinician may adapt his motives to accommodate his cognitive limits and his task. Such a decision may be based on tacit knowledge unavailable to the software analyst.

As a final example, Hogarth [36] and Politser [37] have separately developed support for what can be termed the continuity argument [38]. The essence of this view is that clinical decisions must be viewed as moments in the context of a continuous and changing process or environment. If they are seen instead as discrete or static phenomena, then their relevance as highly functional adaptations to the changing continuum of clinical decisions involving serial information will be missed. Explicit formal systems lack the specific, often tacit, knowledge of the dynamic context and suffer diminished utility as a consequence.

This is not the place to review all the objections to formal decision theory as it has been applied to clinical practice. These three examples are used to illustrate the fact that the clinician acts on the basis of much dynamic and complex knowledge, some of which is tacitly recognized and integrated when he makes clinical judgments. Decision theory as currently formulated is inadequate to the task of incorporating and using all such knowledge, especially the tacit component. When the clinician errs according to the standards of a formal system, it may be as reasonable to challenge the system as the clinician.

Of course, it is not the aim of these formal systems to mimic actual human judgment, only to equal or surpass its decision-making performance [39–41]. Therefore, it is not necessary for such prescriptive expert systems to reproduce the tacit processes occurring in the human mind, just to reach the best judgment. The important question is whether that goal can be achieved by a fully explicit system which ignores whatever unspecifiable tacit knowledge is included in the skill of clinical judgment. To decision theorists and cost-management analysts, it is conceivable that exclusively explicit reasoning can, aided by adequate computing power, identify and manipulate sufficient facts and rules to achieve optimal judgments in complex cases. Those preferring to focus on the role of tacit mental powers are more pessimistic over clinical judgment performed by a formal system, without the clinician's tacit knowledge, routines, integrations, and skills.

Decision trees, algorithms, clinical prediction rules, and formal models are clearly useful in uncomplicated clinical situations [42–45]. The value of these aids in the appropriate context is uncontestable. But even the most sophisticated formal systems may not, in principle, have access to sufficient knowledge for them to equal the capability of clinical intuition in more complex cases. Rather than aid the clinician in such cases, these formal models may actually hinder his intuition by their cumbersome requirements for explicit identification and quantification of all variables.

The context of health care delivery is changing, and decision and cost-management theories are being increasingly applied to the administration and supervision of clinical practice. Decision theory is attractive to policy makers since it appears to offer the opportunity systematically to review and influence clinical practice, pushing it in a direction that seems to favor quality and cost-effectiveness of care. It appears to allow the invention of explicit universal rules that apply to all individual cases. As we have seen, however, the role of tacit knowledge in clinical judgment may define the limits of utility and applicability for decision theory and explicit cost-management policies. These theories and policies may lack essential tacit knowledge, making them prone to failure in complex cases. At minimum, it appears that the recognition of the tacit dimension may necessitate the development of a significantly more dynamic and sophisticated theory of medical decision making before policy makers can use it to influence clinical practice without hindering the exercise of clinical judgment. Until these theories can incorporate such tacitly recognized factors as the constantly changing continuum of clinical decisions, their utility will be limited. Given the increasing encroachment of cost-management systems into the realm of clinical judgment, these latter concerns deserve attention.

Let us now turn to another area where the role of the tacit dimension in clinical judgment is also important: postgraduate medical education. As we have seen, if the expert clinician relies in part upon observance of a set of tacit maxims or routines which are not fully known to him, then the explicit rules of clinical practice are important, but do not fully determine the nature of that practice. When the clinician teaches these explicit rules, he is conveying only one component of his practice, a component which can serve as a guide only when integrated into the complementary tacit component of the operation. It is the union of the partnered tacit and explicit components which generates clinical expertise. But the tacit component is omitted from formal instruction, which necessarily reconstructs and explains only the explicit mental process used. Thus, the expert clinician can only explain to the resident so much of the course of action required. To a significant extent, he must supplement his explicit instruction by imparting his tacit judgment as well, which is best conveyed by demonstrating his skill.

In this way he can also impart the knowledge which inheres within the practice of his skill [20,22,46,47].

This is why so much of medicine is transmitted by example, in the traditional relationship of master and apprentice. It cannot be fully transmitted by explanation or prescription, because no complete prescription exists. This explains the peculiar relationship of the resident or fellow to the expert clinician: To learn by example is to submit to authority. By watching the master and emulating his efforts, the apprentice unconsciously picks up and comes to possess the rules of the art, including those not explicitly known to the master himself. We have seen that to the extent that our clinical knowledge lacks precise formalization, we act by means of unspecifiable knowledge, and the clinician's skill is as much an art of doing as it is an art of knowing. An art of doing is best communicated by example, not by precept. To come to possess such knowledge, a long course of experience under a master is required. In effect, the trainee must come to know personally the basis of clinical judgment through experience under an expert clinician's guidance. Thus, the traditionally long length of the clinical training period attests to the extent to which tacit knowledge has remained unspecifiable at the heart of medicine.

What does all this imply for postgraduate training programs? First, clinical training requires an extended course during which there is substantial exposure to actual clinical practice. It must involve close supervision of the trainee by the expert. Any attempts to shorten the training period, to replace actual clinical exposure with other activity, and to reduce the level of direct supervision of the resident by the attending, may be particularly detrimental in those specialties where clinical judgment is especially complex.

Second, although close supervision is necessary, clinical judgment skills cannot be imparted without substantial opportunity for the residents and fellows to practice the skills. These skills are learned by practice, by doing, and, without such repetition, cannot become instilled. Thus, legislative proposals to diminish the amount of actual practice and responsibility undertaken by residents in training, especially in the surgical fields, are proposals that would hinder efforts to train new clinicians. Such proposals are based on the assumption that the bulk of medical knowledge is conveyed by transmitting explicit rules, rather than by imparting tacit knowledge through repeated example and practice.

In summary, what then are the important consequences of the theory of tacit knowledge for the clinician, educator, or policy maker? First, the tacit dimension of clinical judgment may be significant when determining the structure, length, and goals of postgraduate training programs. The theory leads to the conclusion that the nature of clinical judgment requires a lengthy residency, one in which the novice works closely at the side of the mentor. Furthermore, the resident needs to acquire a critical base of knowledge and experience before he can fully possess and use tacit knowledge. The level at which the physician becomes comfortable with his skill, the point at which clinical practice becomes pleasurable, is only reached after years of training and experience. The theory also suggests that medical training and practice contain knowledge and routines which have evolved over a long period of time, and which should be changed only very cautiously. These routines may exist, in part, for the purpose of imparting tacitly held knowledge which cannot be otherwise conveyed. In fact, the evolved patterns of postgraduate medical education may be a valuable model for other disciplines. Indeed, the emergence and growth of postdoctoral fellowship programs may be a recognition of the fact that knowing-in-action is imparted in many

fields, not just clinical medicine. Through such programs, scientific training is coming more closely to resemble medical training.

Second, the theory suggests that the role for formal decision models in clinical medicine is strictly limited. The inability of these systems to possess and use tacit knowledge limits their capability relative to expert clinical intuition. Although perceived as uniformly cost-effective, these models may often be less cost-effective than encouraging clinicians to utilize their tacit abilities. Such tacit abilities may contain much more knowledge and their use may be far more cost-effective than that of any explicit computer program. Residents and clinicians who are more comfortable running computer programs than using tacit knowledge may prove very expensive in the long run.

Third, and perhaps most important, the theory of tacit knowledge has far-reaching implications for one's personal philosophy of practice and teaching. There is a certain conceit associated with the view that clinicians or policy makers can develop a fully explicit understanding of every issue. This conviction that a decision tree, blueprint, or computer analysis can be used to solve any problem may be a more frequent source of failed schemes than is recognized. It may be preferable to possess a sound recognition of the limitations as well as the capabilities imposed by the nature of clinical judgment.

The concerns raised herein are particularly important since medical education and postgraduate training are receiving increasing scrutiny and revision. Furthermore, at this time of great change in the health care industry, it is clear that clinical practice and health care delivery will be influenced by the view of clinical judgment of the professional cost managers and policy makers. Although it is currently fashionable in both professional policy-making and educational circles to focus less on the tacit dimension of clinical judgment than on the explicit aspects of the process, it may be prudent to recognize equally both components of this partnership of knowledge [48].

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