imaging test ordered (e.g., thoracic CT scan, transesophageal echocardiogram) to evaluate more fully. In nonacute situations, the prevalence of potential alternative diagnoses should play a much more prominent role in diagnostic hypothesis generation.

Cognitive scientists studying the thought processes of expert clinicians have observed that clinicians group data into packets, or "chunks," that are stored in short-term or "working memory" and manipulated to generate diagnostic hypotheses. Because short-term memory can typically retain only 5–9 items at a time, the number of packets that can be actively integrated into hypothesis-generating activities is similarly limited. For this reason, the cognitive shortcuts discussed above play a key role in the generation of diagnostic hypotheses, many of which are discarded as rapidly as they are formed (thereby demonstrating that the distinction between analytic and intuitive reasoning is an arbitrary and simplistic, but nonetheless useful, representation of cognition).

Research into the hypothetico-deductive model of reasoning has had surprising difficulty identifying the elements of the reasoning process that distinguish experts from novices. This has led to a shift from examining the problem-solving process of experts to analyzing the organization of their knowledge. For example, diagnosis may be based on the resemblance of a new case to prior individual instances (exemplars). Experts have a much larger store of memorized cases, for example, visual long-term memory in radiology. However, clinicians do not simply rely on literal recall of specific cases but have constructed elaborate conceptual networks of memorized information or models of disease to aid in arriving at their conclusions. That is, expertise involves an increased ability to connect symptoms, signs, and risk factors to one another in meaningful ways; relate those findings to possible diagnoses; and identify the additional information necessary to confirm the diagnosis.

No single theory accounts for all the key features of expertise in medical diagnosis. Experts have more knowledge about more things and a larger repertoire of cognitive tools to employ in problem solving than do novices. One definition of expertise highlights the ability to make powerful distinctions. In this sense, expertise involves a working knowledge of the diagnostic possibilities and what features distinguish one disease from another. Memorization alone is insufficient. Memorizing a medical textbook would not make one an expert. But having access to detailed and specific relevant information is critically important. Clinicians of the past primarily accessed their own remembered experience. Clinicians of the future will be able to access the experience of large numbers of clinicians using electronic tools, but, as with the memorized textbook, the data alone will not create an instant expert. The expert adds these data to an extensive internalized database of knowledge and experience not available to the novice (and nonexpert).

Despite all the work that has been done to understand expertise, in medicine and other disciplines, it remains uncertain whether there is any didactic program that can accelerate the progression from novice to expert or from experienced clinician to master clinician. Deliberate effortful practice (over an extended period of time, sometimes said to be 10 years or 10,000 practice hours) and personal coaching are two strategies that are often used outside medicine (e.g., music, athletics, chess) to promote expertise. Their use in developing medical expertise and maintaining or enhancing it has not yet been adequately explored.

DIAGNOSTIC VERSUS THERAPEUTIC DECISION MAKING

The modern ideal of medical therapeutic decision making is to "personalize" the recommendation. In the abstract, personalizing treatment involves combining the best available evidence about what works with an individual patient's unique features (e.g., risk factors) and his or her preferences and health goals to craft an optimal treatment recommendation with the patient. Operationally, there are two different and complementary levels of personalization possible: individualizing the evidence for the specific patient based on relevant clinical and other characteristics, and personalizing the patient interaction by incorporating their values, often referred to as shared decision-making, which is critically important, but falls outside the scope of this chapter.

Individualizing the evidence about therapy **does not** mean relying on physician impressions of what works based on personal experience. Because of small sample sizes and rare events, the chance of drawing erroneous causal inferences from one's own clinical experience is very high. For most chronic diseases, therapeutic effectiveness is only demonstrable statistically in patient populations. It would be incorrect to infer with any certainty, for example, that treating a hypertensive patient with angiotensin-converting enzyme (ACE) inhibitors necessarily prevented a stroke from occurring during treatment, or that an untreated patient would definitely have avoided a stroke had he or she been treated. For many chronic diseases, a majority of patients will remain event free regardless of treatment choices; some will have events regardless of which treatment is selected; and those who avoided having an event through treatment cannot be individually identified. Blood pressure lowering, a readily observable surrogate endpoint, does not have a tightly coupled relationship with strokes prevented. Consequently, demonstrating therapeutic effectiveness cannot rely simply on observing the outcome of an individual patient but should instead be based on large groups of patients carefully studied and properly analyzed.

Therapeutic decision making, therefore, should be based on the best available evidence from clinical trials and well-done outcome studies. Authoritative, well-done clinical practice guidelines that synthesize such evidence offer readily available, reliable, and trustworthy information relevant to many treatment decisions clinicians face. However, all guidelines recognize that their "one size fits all" recommendations may not apply to individual patients. Increased attention is now being paid to understand how best to adjust group-level clinical evidence of treatment harms and benefits to account for the absolute level of risks faced by subgroups and even individual patients, using, for example, validated clinical risk scores.

NONCLINICAL INFLUENCES ON CLINICAL DECISION-MAKING

More than a decade of research on variations in clinician practice patterns has shed much light on the forces that shape clinical decisions. These factors can be grouped conceptually into three overlapping categories: (1) factors related to physicians' personal characteristics and practice style, (2) factors related to the practice setting, and (3) factors related to economic incentives.

Factors Related to Practice Style To ensure that necessary care is provided at a high level of quality, physicians fulfill a key role in medical care by serving as the patient's agent. Factors that influence performance in this role include the physician's knowledge, training, and experience. Clearly, physicians cannot practice EBM (described later in the chapter) if they are unfamiliar with the evidence. As would be expected, specialists generally know the evidence in their field better than do generalists. Beyond published evidence and practice guidelines, a major set of influences on physician practice can be subsumed under the general concept of "practice style." The practice style serves to define norms of clinical behavior. Beliefs about effectiveness of different therapies and preferred patterns of diagnostic test use are examples of different facets of a practice style. The physician beliefs that drive these different practice styles may be based on personal experience, recollection, and interpretation of the available medical evidence. For example, heart failure specialists are much more likely than generalists to achieve target doses of ACE inhibitor therapy in their heart failure patients because they are more familiar with what the targets are (as defined by large clinical trials), have more familiarity with the specific drugs (including adverse effects), and are less likely to overreact to foreseeable problems in therapy such as a rise in creatinine levels or asymptomatic hypotension.

Beyond the patient's welfare, physician perceptions about the risk of a malpractice suit resulting from either an erroneous decision or a bad outcome may drive clinical decisions and create a practice referred to as *defensive medicine*. This practice involves using tests and therapies with very small marginal benefit, ostensibly to preclude future criticism should an adverse outcome occur. Without any conscious awareness of a connection to the risk of litigation, however, over time such patterns of care may become accepted as part of the practice norm,