REVIEW ARTICLE

MEDICAL EDUCATION

Educational Strategies to Prepare Trainees for Clinical Uncertainty

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Uncertainty is ubiquitous in medical practice yet is often viewed as a regrettable phenomenon to be tolerated or eradicated.[1] To prepare trainees for practice, teachers need to reframe uncertainty as a central feature of how clinical problems are understood and managed.

Clinicians may go to great lengths to reduce uncertainty, often perceiving it as a threat or source of stress. Multiple cultural forces in medicine reinforce this tendency. Physicians receive extensive training in the biomedical sciences, which are grounded in fixed characterizations and clear classifications.[2] Early medical training comprises case-based discussions and standardized tests that use logical causal pathways to arrive at singular correct answers.[3] Clinical training and practice perpetuate this orientation, with peers, teachers, and patients often reacting negatively to uncertainty or equating it with incompetence.[1,3-5] Structural elements in the workplace, such as the electronic medical record and billing platforms, require unambiguous characterizations of illnesses or treatments, even when clinical problems remain ill-defined.

An aversion to uncertainty can induce subconscious efforts to hide, suppress, or minimize it during daily clinical work. Yet uncertainty cannot be eradicated from clinical practice, even as its frontier shifts with advances in technology and treatments.[6-9] This unyielding reality requires teachers to frame uncertainty not as an undesirable by-product of clinical reasoning but rather as a central feature of it.

This review focuses on the ways in which clinicians recognize and manage in-the-moment experiences of uncertainty in practice and provides practical strategies that teachers can use to help trainees build confidence in managing uncertainty.

EXPERIENCES OF UNCERTAINTY

Much has been written about uncertainty, from the philosophical underpinnings of knowledge to the inherent variability of biologic systems.[2,8] Multiple related terms have been used to describe uncertainty, often with conflicting or overlapping definitions (Table 1).[2,8,10,15,16]

Trainees may have a broad range of uncertainties pertaining to their roles and responsibilities, how they are perceived by colleagues and supervisors, or their emerging identities as physicians.[8,17,18] These uncertainties are beyond the scope of this review. We focus on clinical uncertainty, which characterizes instances in practice when clinicians perceive that they have an incomplete understanding of how to care for a patient[16] and may ask themselves, What is going on? or What should I do?[19] Somatic, emotional, or behavioral cues (e.g., a gut feeling that something is awry or a concern that they are missing something)[19-22] may help clinicians to recognize uncertainty.

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KEY POINTS

EDUCATIONAL STRATEGIES TO PREPARE TRAINEES FOR CLINICAL UNCERTAINTY

Uncertainty is ubiquitous in medical practice. If there was no uncertainty, society would not need physicians to render judgments.

Managing clinical uncertainty is a foundational skill for a physician and is central to effective clinical reasoning.

Clinicians recognize uncertainty through a range of cues and navigate these experiences by using cyclic processes of forward planning and monitoring.

Teachers can equip trainees to manage uncertainty by encouraging discussions about potential sources of uncertainty (diagnosis, treatment, or prognosis) and types of uncertainty (epistemic [for which additional information might reframe or reduce uncertainty] or aleatoric [for which outcomes are inherently variable]). This characterization can help trainees understand, manage, and communicate uncertainty.

Teachers should reframe uncertainty as a signal that there are opportunities for learning.

Technology will not resolve uncertainty; it just shifts the locus of uncertainty.

A hypothetical case illustrates a range of uncertainties that a first-year resident may have while evaluating a patient presenting at an outpatient clinic with shortness of breath (see the interactive graphic). The resident may question whether he actually detected distended neck veins or which initial treatments to select. He may be uncertain about what resources will be needed if the patient s clinical status suddenly worsens or where he can find help. In considering these possibilities, the resident may also wonder whether his discomfort is an expected part of encountering unfamiliar problems during training or whether these reactions signal concerns that will be shared by his supervisor.[23]

There is an extensive body of literature on how doctors think through clinical problems.[24-26] These insights allow teachers to draw on ideas about knowledge structures (e.g., illness scripts and diagnostic schemas),[27] modes of thinking (e.g., intuitive or analytical reasoning),[24] cognitive tendencies (e.g., heuristics and biases),[28,29] and statistical characterizations of tests and treatments (e.g., evidence-based medicine).[30] These concepts help trainees and their teachers chart the cognitive path from presentation to diagnosis and treatment.

Yet as the case in the interactive graphic shows, a different set of skills is required to help trainees manage the moments along this pathway where uncertainty is manifested. To move through uncertainty, clinicians use cues from themselves, their patients, and the environment to monitor their progress and shift their approaches in real time.[11] Effective teaching conveys that uncertainty is not to be avoided but rather is a reality of practice that can be identified and managed. In guiding trainees through these situations, teachers can emphasize how experiences with clinical uncertainty signal opportunities for learning.[31]

It is important for clinical teachers to note that trainees perspectives on clinical uncertainty are different from their own, even when caring for the same patient. These differences stem from trainees developing knowledge or skills, lack of familiarity with the equipment or interprofessional team structures around them, or limited experience with similar situations in practice.[8] Trainees may lack confidence in their abilities to gather data from the physical examination or make judgments about ill-defined situations, even when their approaches align with those of their supervisors.[23] Clinical teachers serve a critical role in pointing out and naming trainees uncertainties and in showing them how to proceed safely even when their understanding of a clinical situation is incomplete.

An interactive graphic is available at NEJM.org

UNCERTAINTY AS A TRAIT OR STATE

Case presentations are often the first opportunity for teachers to probe trainees understanding of clinical problems and their capacity to manage uncertainty. As the resident in the example presents his patient with shortness of breath, the teacher might note that the resident has reservations about his proposed diagnosis or expresses concern (e.g., using the word worried) when discussing a plan. The teacher might wonder whether the trainee is ill-suited to managing the uncertainties of clinical practice or is simply having a developmentally appropriate reaction to an unfamiliar situation.

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Table 1. Working Definitions of Uncertainty and Related Terms.

Term	Definition
Uncertainty	A sense of being unsure or having doubt; risk (often incalculable), ambiguity, and complexity contribute to this feeling
Clinical uncertainty	Incomplete confidence in one s understanding of a clinical situation, often accompanied by such thoughts as what is going on? or what should I do? [10-13]
Probability	The likelihood of a future event
Risk	The possibility or probability of harm, loss, or a negative outcome
Ambiguity	Missing, imprecise, or conflicting information that is needed for decision making, or information that can be interpreted in two or more distinct ways (e.g., whether an infiltrate is present on a chest x-ray)[14]
Complexity	Multiple components of a situation that interact in diverse ways, which can lead to unpredictable outcomes, or patterns that are difficult to understand

The literature offers two general vantage points on how clinicians encounter and manage uncertainty. The first perspective treats physicians capacity to handle uncertainty as a stable personality trait across a range of experiences. Several scales have been used to measure the reactions of physicians to hypothetical experiences of uncertainty,[20,32] creating a profile of uncertainty tolerance on the basis of statements such as uncertainty in patient care makes me uneasy or I am quite comfortable with the uncertainty in patient care. [33] Lower uncertainty tolerance on these scales has been associated with higher rates of burnout, lower career satisfaction, and specialty choice.[34-36]

A second perspective on uncertainty is that it emerges in the moment (as a state), which reflects the idiosyncratic ways that knowledge and skills intersect with clinical problems in context.[11] This idea arises from the literature of self-regulation, which describes how people use cues from themselves and the world to recognize uncertainty and make judgments about their capacity to handle these situations (Fig. 1).[37] Surgeons are able to recognize moments when they slow down as a subconscious reaction to operative uncertainty (e.g., on encountering an adherent tumor) and often notice this behavior even before they are able to articulate their specific concerns.[22] In recognizing such moments of uncertainty, ex-

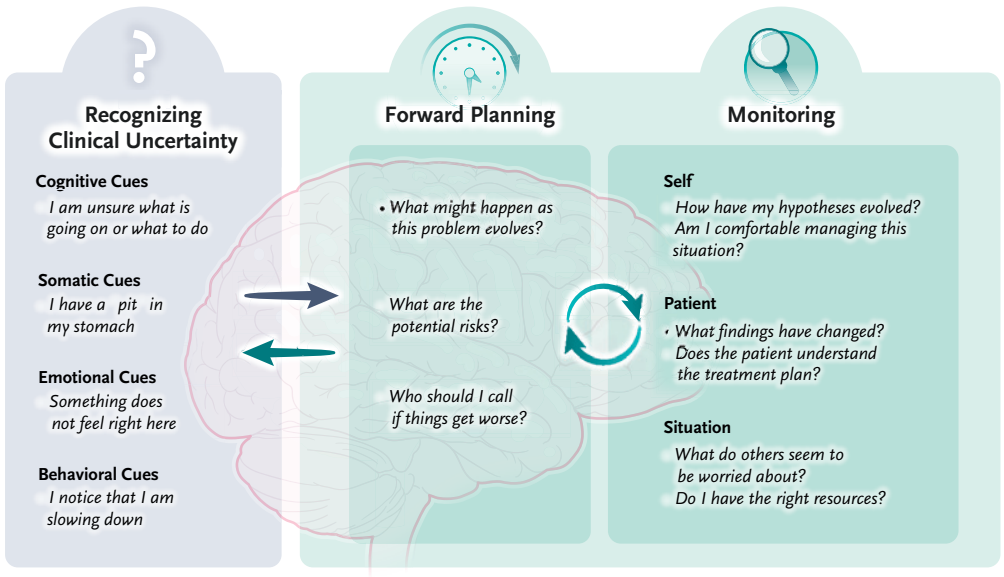

Figure 1. A Conceptual Model of How Clinicians Manage Clinical Uncertainty.
Clinicians recognize uncertainty through a range of cognitive, somatic, emotional, and behavioral cues and manage these experiences over time through cyclic processes of forward planning and monitoring, which can, in turn, reveal new uncertainties. These processes are highly dynamic and are shaped by evolving clinical findings and contexts.

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perts devote more mental effort to the situation, minimize distractions, and approach the task with heightened vigilance to maximize patient safety.[21]

A trainee s response to uncertainty can be characterized as both a trait and a state, and teachers are in a position to influence both dimensions. As shown in the interactive graphic, the teacher may call attention to the trainee s words (I heard you say worried) and highlight how emotional reactions can signal a sense of uncertainty that is specific to the situation. Repeated discussions about uncertainty coupled with management strategies will help trainees build confidence to tackle uncertainty across a wide range of problems and situations.

In the case example, the teacher s early concern about the trainee s general capability to manage uncertainty (trait) may have been premature. Instead, the teacher could have recognized that there was a misalignment between the trainee s abilities and the demands of the situation (state). The teacher s ability to encourage the trainee to lean into and learn from uncertainty will enhance the trainee s ability to manage it in that moment and also instill generalizable lessons for future experiences of clinical uncertainty.

HOW EXPERIENCED CLINICIANS MANAGE UNCERTAINTY

Teachers can model how they manage uncertainty. After evaluating the patient with shortness of breath, the teacher might raise concerns pertaining to the range of possibilities that she is thinking about, such as whether expedited imaging is needed to rule out a pulmonary embolism or whether the patient needs to go to the emergency department for bronchodilator treatments. Alternatively, the teacher might articulate how specific aspects of the situation reassure her that the patient s problem can be managed on an outpatient basis, even while she remains uncertain about what might happen.

Two concepts described in studies of practicing clinicians can serve as examples of how teachers can explain their approach to uncertainty for trainees. First, experienced clinicians use forward planning to simulate how a problem might evolve, drawing on their knowledge and past experiences to forecast what could happen, think through contingencies, and put safety plans in place.[11,22,38] In building an outpatient plan to manage the patient s shortness of breath, for example, the teacher might describe how she thinks through whether diagnostic tests are feasible in the patient s social context, warning signs they can educate the patient and family about, and follow-up plans, such as a telephone call the next day to ensure that their management approaches remain on track.

Experienced clinicians also manage uncertainty through monitoring. Although this term is typically equated with the ways that clinicians watch the evolving clinical picture and the patient s response to therapy, a more expansive definition of monitoring encompasses how experienced clinicians pay attention to a broader range of cues from patients, from their own reactions, and from their environment to continually revisit their ideas about what is going on and how they might handle a situation.[11,21,39] For example, in the acute care setting, the teacher could share what she is noticing in herself (an internal state of calm or worry) or what she is noticing in others (the respiratory therapist hovering in the doorway) and how she is integrating these signals into her overall level of comfort with the situation.[11,21,40] The teacher may share with the trainee how the reassurance of the nurse, the stability of the oxygen saturation during the encounter, and the ability of the patient s spouse to check in through telehealth services the next day allow them to comfortably manage an uncertain situation in which the short-term prognosis is clearer than the long-term diagnosis.

By modeling the cyclical processes of forward planning and monitoring (Fig. 1), teachers can elaborate how they pay attention to evolving clinical problems and prepare for potential risks as diagnostic and management processes unfold over time. In the interactive graphic, the teacher can talk through her forward planning for the patient with shortness of breath, imagining how things could go wrong in the future and asking what can be done now to reduce or prepare for those possibilities.[41,42] She might envision a scenario in which the patient did not understand how to use newly prescribed inhalers and therefore needed to go to the emergency department. To avoid this scenario, the teacher could encourage the resident to make an extra effort to instruct the patient on the proper technique for using the inhaler, emphasize teach-back commu-

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nication to gauge the patient s level of understanding,[43] and schedule a check-in video call with the patient the following day to assess the patient s dyspnea and inhaler technique.

RECOMMENDATIONS FOR TEACHERS

Teachers can use multiple strategies to normalize uncertainty as the inherent state of medical practice and a core aspect of clinical reasoning.[44] Several of these strategies can be integrated into clinical settings (Table 2), and others can be used in classroom-based or simulation-based teaching. Many of these recommendations are grounded in the psychology and education literatures but require empirical validation. Although there is no prescriptive arc to teaching about uncertainty, it often involves recognition, appraisal, management, and reflection.[45]

NARRATING UNCERTAINTY

Thinking out loud about a clinical problem enables teachers to narrate the ways in which uncertainty is challenging. They may share sentiments such as I m not sure of the diagnosis or Something does not feel right here,[46,47] and describe how they use these reactions for planning and monitoring. Such routine disclosures can normalize uncertainty and enhance the culture of the clinical learning environment so that trainees can say, I don t know and share their concerns freely, with the expectation that their teachers will do the same.[48] An uncertainty check, in which teachers ask trainees how confident they are about the diagnosis or plan, is an easy method for revealing clinical uncertainty and prompting a discussion.

Articulation of if then plans is an effective way of highlighting the aspects of cases that trainees should pay the most attention to and stopping points at which they should seek assistance.[19] For instance, a hospitalist may point out, Although fevers during the first 1 or 2 days of intravenous antibiotics for pyelonephritis are typical, I m less comfortable with fevers at the 72-hour mark that s when I would order a CT scan to rule out nephrolithiasis or renal abscess.

FRAMING UNCERTAINTY

Because uncertainty emerges at every point along the continuum of care and often operates subconsciously as a sense of unease,[21,46] it can be helpful to frame its location and source. After a trainee articulates uncertainty or the teacher detects it in the trainee s language or behavior, the teacher can guide the trainee to reflect on whether the uncertainty pertains to the diagnosis, treatment, prognosis, or workplace dynamics. The teacher can further probe the origins of trainees uncertainties by asking them to consider whether the issue is one of limited knowledge or information that can be addressed (epistemic uncertainty) or whether the issue reflects irreducible randomness in biomedical and health systems (aleatoric uncertainty).[49]

Framing can provide structure to the conversation between teachers and trainees. It may be useful for teachers to classify clinical uncertainty as epistemic (e.g., Is there evidence to support the safety of beta-blockers in a patient with cocaine ingestion?) or aleatoric (e.g., Could the patient have an adverse drug reaction?). Although this distinction may prove difficult to establish in complex situations, efforts to categorize a range of uncertainties can prompt trainees to map out their next steps, which might include gauging the probability of an event or thinking through contingencies for less predictable or worst-case scenarios. This framing can help teachers decide whether they should resolve uncertainty for trainees directly (by imparting information or sharing past experiences) or leave this work for trainees to explore and figure out on their own (e.g., by using online resources or asking others for input).[48] With practice, trainees will develop a repertoire of strategies (e.g., monitoring patients responses to treatment in order to navigate aleatoric uncertainty) and build confidence in separating uncertainty that is a natural consequence of learning from the unresolvable uncertainties of clinical practice.[23]

SIMULATING UNCERTAINTY

One way to prepare trainees for uncertainty is to reimagine how we simulate practice outside clinical settings. Case-based conferences and simulations are often structured to be linear, logical, and solvable in order to convey the foundational knowledge of diagnosis and management.[50] At more advanced training levels, teachers can shift case conferences toward scenarios with a range of reasonable options and multiple irresolvable dilemmas.[51] For instance, a case of acute monoarthritis with findings that are compatible with

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Table 2. Precepting Strategies to Help Trainees Manage Clinical Uncertainty in the Moment.

Skill	Situation or Clue	Educational Diagnosis	Educational Strategy	Example of Strategy
Narrating uncertainty	Trainee presents a polished and clear-cut assessment without mentioning uncertainties stemming from the history and physical examination.	Trainee may be oversimplifying to project greater certainty and confidence.	Reintegrate discrepant history or examination findings to raise questions about working hypotheses.	I wonder how this rash might change our thinking. It s normal to have things that do not seem to fit with our working diagnosis.
Framing uncertainty	Trainee presents a wide range of uncertainties, from specific questions about diagnosis and management to broader questions about evidence or practice variation.	Trainee may benefit from strategies to organize these uncertainties.	Help trainee to stratify issues as epistemic (for which additional information might reframe or reduce uncertainty) or aleatoric (for which outcomes are inherently variable).	You have highlighted several important questions about this case. Where should we seek information to reduce uncertainty at this point? What aspects of this case are likely to remain unknowable or unpredictable no matter what we do?
Forward planning	Trainee concludes discussions about the patient without mapping out contingencies for adverse outcomes.	Trainee may not have the same differential diagnosis in mind that the teacher has or may not share the same concerns about risks and may also lack experience with the problem.	Challenge the trainee to think about different ways the case might unfold and how the trainee would respond.	What are three different potential outcomes for the plan we are putting in place? What can you do right now to prepare for those possibilities?
Patient monitoring	Trainee concludes discussion about a patient without specific plans for monitoring the patient s course.	Trainee may not know what findings are important to look for as a case evolves or treatments are started.	Highlight the key findings to monitor in order to determine whether the diagnosis and management are on track.	When do you plan to evaluate this patient again? What kinds of signals are you looking for? How might the development of fever change your thinking or management?
Self-monitoring	Trainee expresses worries during case presentation, or teacher notices behavior suggesting that the trainee may be concerned or anxious about the case.	Trainee may not recognize emotional or somatic cues as helpful signals of uncertainty.	Probe the trainee s reactions and validate them as valuable signals that can be used to manage uncertainty.	I heard you say worry during your case presentation, and I am having the same reaction to this case. Let s compare the elements that are making each of us uncertain and why they are raising concerns.
Monitoring others	Trainee overlooks other health professionals actions or language signaling that they are thinking about the situation differently.	Trainee may be unaware of how a particular health care team works together, including moments when others are trying to signal their concerns.	Share your interpretations about the behavior and language used by other health care professionals.	The nurse s tone of voice and frequent updates suggest concern about this patient. What strategies might you use to explore the nurse s thinking?
Communicating uncertainty	Teacher notices that the trainee does not disclose uncertainty to the patient.	Trainee may be concerned that revealing uncertainty could undermine the patient s confidence in the trainee s skills.	Model how you share uncertainty with the patient, including inviting the patient to help guide the monitoring plan.	Pay attention to how I start the conversation by stating that we think the diagnosis is gout but that we will continue to consider cellulitis as an alternative diagnosis. I will then ask the patient to share his understanding and concerns. The patient and I will discuss a range of options to help build a plan that we can both be comfortable with.

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both crystalline and infectious arthritis would prompt learners to navigate aspects of management without the benefit of a definitive diagnosis. In case formats that involve uncertainty,[52] discussion would be directed toward how trainees define and navigate these dilemmas in real time, such as the nondefinitive nature of cell-count thresholds in synovial fluid, unease associated with engaging a consultant overnight, or concern about whether a patient can afford the prescribed treatment.

Clinical experiences can also be simulated with the use of high-fidelity manikins or interactive online cases that recreate the kinds of uncertainties that clinicians wrestle with in practice. In working through scenarios with a broad range of uncertainties, teachers can invite trainees to freeze time and discuss the cues they are noticing in themselves and others, describe their evolving understanding of the situation, and discuss a range of management approaches.[53] Simulating authentic experiences requires deliberately selecting cases in which solutions to diagnostic or management challenges remain unclear, even to the teacher. One such case might prompt trainees to consider how to safely manage cervical spine immobilization without intravenous access in an agitated patient who cannot lie flat for imaging.[54]

For each of these situations in which trainees grapple with ill-defined problems, the role of the teacher is different from that in the typical case conference or simulation. Rather than providing answers to known problems (e.g., This patient had an aortic dissection, the management of which consists of), teachers narrate their approaches as teaching tools (e.g., I have had tough cases like this, and these are a couple of strategies that helped as I struggled to untangle what was going on). Such dialogue between trainees and teachers can highlight different reactions to uncertainty and show how teachers integrate these cues into forward planning and monitoring (e.g., It made me nervous when I saw his oxygen saturation drop, and I started thinking about where to find the intubation equipment). Teachers can also share stories of past experiences that portray how their efforts to enact safe management steps are tentatively informed by what has worked for them previously (e.g., I typically try a fluid bolus, but we will see whether that works here).

COMMUNICATING UNCERTAINTY

Structured communication tools can enhance how trainees communicate their uncertainty to supervisors, colleagues, and patients. Case presentation models that embed steps for students to ask questions (e.g., I am wondering why the patient still has a cough) give them opportunities to query supervisors about points of uncertainty.[55,56] The use of handoff tools during transitions of care can prompt clinicians to share their degree of diagnostic uncertainty with peers (some uncertainty, marked uncertainty, or a high degree of uncertainty).[57] Multiple resources are available to teach trainees how to communicate uncertainty to patients,[58,59] including learning how to describe it and how to assess a patient s comfort with such messages.[60,61] For example, a vignette study showed that families preferred communication of diagnostic uncertainty that included differential diagnoses (The pain is most likely caused by an ankle sprain, although gout is a possibility) over more general expressions of uncertainty (I m not sure what is causing the pain).[4]

CONCLUSIONS

Uncertainty is ubiquitous in clinical practice, and learning how to manage it is essential for clinicians in training. The concepts and techniques described in this article are intended to help teachers foster an educational culture in which uncertainty is spotlighted, managed strategically, and embraced as an inherent and rewarding aspect of medical practice.

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