A 1-year-old child who emigrated from Africa at 8 months of age was admitted for evaluation of failure to thrive (FTT) and hypotonia. Her birth weight was 3.35 kg (46th percentile), and on hospital admission, she weighed 6.2 kg (0 percentile). Her mother had full prenatal care in Africa and was HIV negative in her third trimester. The child was exclusively breast fed until 6 months when she was converted to formula and various foods customary to her culture. In addition to 4 bottles of formula per day of varying volumes, the mother offered pureed baby food such as vegetables and fruits, but her daughter refused. Two months before admission, she was referred to an outpatient neurologist for hypotonia, who recommended a brain magnetic resonance imaging scan if increased caloric intake did not improve weight gain and decrease hypotonia, but the family was lost to follow-up. On examination, she had preserved head circumference with short limbs and a prominent forehead. She sat unassisted and crawled but did not cruise or walk. Her appendicular tone was low, but the remainder of her physical examination, including axial tone, was normal.

If we polled 100 pediatric hospitalists about their recommended first steps in this patient’s evaluation, we would likely receive many different answers. Some would focus on the international aspect of this presentation and pursue testing for HIV or tuberculosis. Others would consider the hypotonia a clue to a neurologic or genetic etiology, and some might pursue a standard assessment of daily caloric intake before addressing other unique aspects of the presentation. Finally, some would pursue these etiologies concurrently. With so many potential directions to embark on the diagnostic workup, the clinician would be wise to take a step back and prioritize the areas of greatest uncertainty before launching into an extensive workup. In this commentary, we discuss a probabilistic approach to diagnostics, where this fits into the broader challenge of managing uncertainty in health care, and how an improved understanding of these concepts may enhance value in inpatient pediatrics.

Medical decision-making is about assessing risk and weighing competing probabilities in the setting of imperfect information. A patient either does or does not have a condition for which we are considering testing, and since we lack omniscience, we are stuck with the inconvenient reality of not being able to distinguish between the two. Based upon the (admittedly subjective) information collected in our history and physical examinations, we can apply probabilistic thinking to internal and external databases to better characterize risk and order differential diagnoses. If we are able to assign a reasonable prior probability of disease for each possible diagnosis, we can then use existing test characteristics to assess the likelihood that a particular test will be diagnostically helpful (ie, decrease our uncertainty).
For a variety of clinical situations, pediatricians perform these functions intuitively. When approaching the initial evaluation of the 1-year-old child presented here, for instance, we consider the various components of her presentation and may generate a mental ordering of what is most likely. We may consider the biases that influence this ordering, including the disproportionate weight of recent cases and diagnostic inertia from the previous care team. Rarely, however, do physicians articulate this mental ordering in the form of discrete probabilities. In a survey of internists, only 2 of 300 clinicians regularly used the concepts of prior probabilities and likelihood ratios in medical decision making. Diagnostic tools like the threshold model of medical decision making, which encourages the establishment of test and treatment thresholds and applies test characteristics such as sensitivity and specificity to understanding how a given clinical test may or may not help achieve certainty beyond these thresholds can help clinicians operationalize these concepts into decision support tools for relatively straight forward problems (eg, rapid strep testing). For more complex problems, like the above case, a more nuanced understanding of the nature of uncertainty may help.

Experts in the field of decision science have attempted to better characterize uncertainty, proposing a conceptual taxonomy of uncertainty in health care adapted from fields such as engineering and risk analysis. They argue that uncertainty in health care can be broken down into two related dimensions: theoretical sources and practical issues. The sources represent the causes of uncertainty in any given situation, which include probability, ambiguity, and complexity. The issues represent the domains of uncertainty clinicians or patients encounter clinically, namely scientific, practical, and personal. While personal and practical issues of uncertainty can contribute to diagnostic uncertainty – as they do in this case, diagnosis is considered a scientific issue. Relating the primary issue of uncertainty (diagnosis) to its source for this particular case, we asked the question, what is the probability that the appendicular hypotonia was the result of FTT?

A focused literature review can help to answer this question. The underlying cause of FTT is most commonly inadequate dietary intake, usually related to abnormal feeding behavior and psychosocial factors. Additionally, neurodevelopmental delays are commonly associated with FTT, especially in severely malnourished, hospitalized children. Children with FTT, in both developed and developing nations, consistently exhibit poorer scores in tests of cognitive, neurological, and psychomotor development, with the strongest association found with poor neurodevelopmental outcomes. Subtle dysmorphic features add complexity to this case, but for a given patient with these presenting symptoms, the evidence suggests that the prior probability of a unifying neurologic etiology is much lower than a psychosocial cause.

After addressing the primary issue of scientific uncertainty, we focused on practical and personal issues of uncertainty, considering the patient’s surrounding environment in her clinical presentation. From a psychosocial perspective, the patient’s mother, who recently immigrated to a new country, may have been experiencing unmet basic needs and social isolation. She may have been unable to offer sufficient calories to her child. Poor access (or poor perceived access) to health care may have caused a small avertable problem, such as early conversion and dependence on whole milk, to become compounded into the larger acute problem. Prioritizing these potential issues of uncertainty, we focused the patient’s evaluation on observation of social interactions, assessment of weight gain with nasogastric feeding, and dependence on whole milk, to become compounded into the larger acute problem. Prioritizing these potential issues of uncertainty, we focused the patient’s evaluation on observation of social interactions, assessment of weight gain with nasogastric feeding, and dependence on whole milk, to become compounded into the larger acute problem.

The unusual nature of this case and uncommon diagnosis leads to an important follow-up question: does a probabilistic approach to medical decision-making lead to greater value of the care provided? If one defines value narrowly as outcomes divided by cost, a cogent argument could be made for a more generalized diagnostic approach (ie, pursuing all potential etiologies at once) to this patient’s workup, especially if the step-wise probabilistic approach led to potential delays in diagnosis, a prolonged hospital stay, and, in the setting of per diem reimbursement, higher cost. In other words, better value to the patient may mean arriving at the correct diagnosis as quickly as possible, especially in the inpatient setting. So why not perform additional studies to “rule-out” a potential neurologic etiology for this patient’s presentation?

As many physicians are aware, 1 more test can harm. Incidental findings on brain magnetic resonance imaging are common in children, occurring in approximately one-tenth of healthy subjects, with variation in prevalence depending on age, race, and imaging modality resolution. As a recent commentary described, “rule-out begets more rule-outs, more tests, and more uncertainty.” If a patient needed sedation for additional diagnostic imaging, that too comes with risk. Anesthetic exposure to the developing pediatric brain is associated with subsequent developmental and behavior disorders, increasing with greater cumulative exposure. Financial harm is an additional risk from inappropriate testing. Patients may be left liable for the differential between insurance companies payments and hospital charges. This is most obvious when a patient lacks insurance.

Sound clinical reasoning that incorporates a probabilistic approach and a strategy for identifying and managing uncertainty should drive diagnostic decision-making. Though some have argued that doctors are not good gamblers, by more clearly identifying the issues and sources of uncertainty and using probabilistic thinking to guide reasoned bets, physicians can become better consumers of data. As this case demonstrates, these basic concepts can be helpful even in absence of precise calculations. By focusing on improving outcomes for patients and reducing costs that might be accrued attempting to eliminate uncertainty instead of manage it,
the value of the care pediatricians provide will improve.

REFERENCES


7. Jha S. Stop hunting for zebras in Texas: end the diagnostic culture of “rule-out.” BMJ. 2014;348:g2625


# Probability, Uncertainty, and Value in Inpatient Diagnosis: Connecting the Dots

Brian P. Jenssen and Chén C. Kenyon

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