The Decisive Influence of the Diagnostic Environment on Diagnostic Reasoning in Practice

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Abstract

This article argues that diagnostic reasoning in clinical practice is decisively shaped by the environment in which diagnosis occurs. Because diseases present with different prior probabilities in different patients, prescribed Bayesian reasoning may fail to promote diagnostic accuracy and may contribute to missed diagnoses. The article contends that the frequentist reasoning used in practice is better suited to this environment because it treats suspected diseases as hypotheses to be tested and relies, where possible, on highly informative test results calibrated by their diagnostic performance.

Keywords

diagnostic reasoning, Bayesian reasoning, frequentist reasoning, diagnostic accuracy, likelihood ratios

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It is well known from experience that diagnosis in practice is performed in an environment in which every disease is known to occur with varying presentations and thus with varying prior probabilities in different patients. The goal in diagnosis in practice is to diagnose a disease accurately in a patient with symptoms regardless of its prior probability so that it can be treated and prognosticated properly. Acute myocardial infarction (MI), for example, can present in both high-risk patients, like a 65-year-old man with classic chest pain, and low-risk individuals, such as a healthy 40-year-old woman with atypical chest pain. The goal for both of these patients is to diagnose acute MI accurately when they present to us in practice. I shall argue in this article that diagnostic reasoning employed in practice to diagnose a disease accurately in every patient is decisively influenced by the environment of diagnosis.

First, I will assess whether prescribed Bayesian reasoning (Weinstein et al. (1980: *Clinical Decision Analysis*, Philadelphia: W.B. Saunders Company)) is employed for diagnosis. This reasoning has been prescribed for inferring an uncertain event in every field, including diagnosis, primarily due to its coherence (Edwards, Lindman and Savage (1963: "Bayesian Statistical Inference for Psychological Research", *Psychological Review* 70(3), doi: 10.1037/h0044139, 193–242); Weiss and Weiss (eds) (2009: *A Science of Decision Making: The Legacy of Ward Edwards*, Oxford University Press, doi: 10.1093/acprof:oso/9780195322989.001.0001)). It is considered coherent due to its seamless updating of a prior degree of belief in an event (disease), represented by its prior probability, by an observed test result to a total degree of belief in an event (disease), represented by its posterior probability, from which it is inferred (diagnosed). We do not find any mention or discussion of the diagnostic accuracy of Bayesian reasoning in practice in this prescription. It appears simply to have been assumed that the coherence of Bayesian reasoning ensures its diagnostic accuracy in practice.

But when we look for evidence of prescribed Bayesian diagnostic reasoning in practice, we are hard pressed to find it. We do not find it, for example, in any of the scores of published diagnostic

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exercises in real patients, such as in clinicopathologic conferences (CPCs) and in clinical problem-solving exercises (Jain (2016a: "An Investigation into Method of Diagnosis in Clinicopathologic Conferences (CPCs)", *Diagnosis* 3(2), doi: 10.1515/dx-2015-0034, 61–64); Jain (2016b: "Why Is Diagnosis Not Probabilistic in Clinical-Pathological Conference (CPCs): Point", *Diagnosis* 3(3), doi: 10.1515/dx-2016-0012, 95–97)). We do not find the key Bayesian notions of interpretation of a prior probability as a prior degree of belief and diagnosis of a disease from its posterior probability to be employed in any of these exercises. The prescribed Bayesian diagnostic reasoning is not employed in practice, I suggest, as it fails to promote diagnostic accuracy in any way; on the contrary, it tends to cause diagnostic errors, as I discuss below.

A low prior probability of a disease with an atypical presentation will be interpreted as a weak prior degree of belief in it in Bayesian diagnostic reasoning, which may cause this disease not to be suspected and tested, leading to a diagnostic error. Thus, this reasoning appears to encourage diagnostic errors due to failure to suspect a disease with an atypical presentation, which have been reported in several studies (Ely, Kaldjian and D'Alessandro (2012: "Diagnostic Errors in Primary Care: Lessons Learned", *Journal of the American Board of Family Medicine* 25(1), doi: 10.3122/jabfm.2012.01.110174, 87–97); Singh et al. (2013: "Types and Origins of Diagnostic Errors in Primary Care Settings", *JAMA Internal Medicine* 173(6), doi: 10.1001/jamainternmed.2013.2777, 418–425)).

In addition, diagnosis of a disease in Bayesian reasoning from its posterior probability, which is generated from its prior probability and the likelihood ratio (LR) of a test result, causes a diagnostic error, as we see in the following real patient case, discussed in a clinical problem-solving exercise, in which Bayesian diagnostic reasoning is attempted (Pauker and Kopelman (1992: "How Sure Is Sure Enough?", *New England Journal of Medicine* 326(10), doi: 10.1056/NEJM199203053261007, 688–691)).

This patient is a healthy 40-year-old woman who presents with atypical chest pain. An electrocardiogram (EKG) reveals acute ST elevation changes, a highly informative finding with an LR of 13. In Bayesian reasoning, which is initially attempted in this patient, the low prior probability of acute MI of 7% is combined with an LR of 13 for the test result to generate a posterior probability of 50%, on the basis of which the diagnosis of acute MI would be considered indeterminate. However, the physician discussing the case in this exercise does not accept this Bayesian diagnosis as accurate, stating that it is not supported by his experience. Instead, he interprets the highly informative test result, acute ST elevation EKG changes with an LR of 13, as strong evidence from which he diagnoses acute MI accurately with a high degree of confidence by frequentist reasoning that I have described in detail elsewhere (Jain (2024: "Diagnostic Reasoning in Practice Is Frequentist", *The Reasoner* 18(3), `https://riviste.unimi.it/index.php/thereasoner/article/view/24099`, 22–24)).

Thus, we note that Bayesian diagnostic reasoning is not employed in practice, despite being prescribed, in a diagnostic environment in which every disease occurs with varying prior probabilities in different patients. If this environment were different—for example, if every disease in practice occurred with the same prior probability in different patients, then perhaps Bayesian diagnostic reasoning could be employed to diagnose diseases accurately in practice.

As I have discussed elsewhere (Jain (2024: 22–24)), it is frequentist diagnostic reasoning that is employed in practice, as

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it is highly successful in diagnosing diseases accurately in an environment in which every disease occurs with varying prior probabilities in different patients. The reported high diagnostic accuracy rate of 85–90% in practice (Berner and Graber (2008: "Overconfidence as a Cause of Diagnostic Error in Medicine", *American Journal of Medicine* 121(5 Suppl.), doi: 10.1016/j.amjmed.2008.01.001, S2–S23)), I suggest, is due to the use of frequentist diagnostic reasoning. Two primary aspects of this reasoning, discussed below, contribute significantly to its practical effectiveness.

First of all, every suspected disease is formulated as a hypothesis only, without interpreting its prior probability as a prior degree of belief or prior evidence. This enables comprehensive testing and reliable diagnosis of virtually all suspected diseases, including those with low pre-test probabilities, when they are present in patients.

Then, as far as possible, a disease is diagnosed from a highly informative test result with an LR greater than 10. Such a result is interpreted as strong evidence on the basis of the test's diagnostic performance: it diagnoses the disease accurately with a frequency of 85% or higher in a random sample of patients with varying prior probabilities in whom the disease is suspected (Jain (2024: 22–24)). This makes frequentist diagnosis of a disease in a patient highly reliable, as it is calibrated by its accuracy in a random sample. These test results are used to diagnose many diseases, such as acute MI, pulmonary embolism, deep vein thrombosis, and COVID-19, in practice (Jain (2024: 22–24)).

In conclusion, I have argued in this article that frequentist reasoning, rather than prescribed Bayesian diagnostic reasoning, is employed in practice because it succeeds in diagnosing diseases accurately in an environment in which they occur with varying prior probabilities in different patients.

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