The Bayesian method has been prescribed as the normatively correct method of diagnosis in theory (1). In this method, the prior probability of a disease suspected from a presentation in a patient is interpreted as subjective prior degree of belief in it. It is combined with the likelihood ratio (LR) of result of a test done to evaluate the suspected disease to generate a posterior probability which is interpreted as subjective total degree of belief from which the disease is inferred in the patient. But when we examine the process of diagnosis in practice, we find the Bayesian method not to be employed. For example, we find a disease not to be inferred from a posterior probability generated by combining a prior probability and LR in any of the hundreds of published diagnostic exercises in real patients such as clinical-pathologic conferences (CPCs) and clinical problem solving exercises clearly indicating the Bayesian method has not been employed in them (2,3). In this paper, we shall look at the consequences of employing the Bayesian method for diagnosis to understand why it has not been employed in practice.

The first patient we look at is a real patient discussed in a clinical problem solving exercise (4) who is a healthy 40 year old woman presenting with highly uncharacteristic chest pain in whom acute myocardial infarction (MI) is suspected and an EKG performed to evaluate it which reveals acute ST elevation EKG changes that have a LR of 13 (5). If we employ the Bayesian method for diagnosis in this patient, we would estimate the prior probability of acute MI to be 7 percent from its prevalence which we would interpret as very strong subjective degree of belief against it in this patient. We would then combine this prior probability with the LR of 13 for acute ST elevation EKG changes to generate a posterior probability of 50 percent (Appendix 1), which would be interpreted as equivocal degree of belief from which acute MI would be inferred to be indeterminate in this.

There are two issues with the Bayesian method of diagnosis, in our view, in this patient. It is not clear what purpose is served by interpreting the very low prior probability as very strong subjective degree of belief against acute MI in this patient. This interpretation poses a risk, we believe, of ruling out acute MI without testing, which would be committing a diagnostic error as this patient actually had acute MI. And if it is not employed to rule out acute MI and we proceed to do testing anyway, why then bother to interpret this prior probability as a subjective degree of belief against acute MI. Other investigators have also raised this issue about the Bayesian method. For example, the applied statistician, Ehrenberg (6) has noted that if the prior is weak, why bother to proceed with inference

The second issue is about the reliability of the Bayesian diagnosis of acute MI being indeterminate from the posterior probability of 50 percent, which is interpreted as a subjective total degree of belief. We have no idea about the reliability of this diagnosis as it is based on a subjective degree of belief which is not validated by our experience.

Due to these two issues, we note, the Bayesian method is not actually employed for diagnosis in this patient in the clinical problem solving exercise, in which we find the suspected acute MI is formulated merely as a hypothesis without its prior probability being interpreted as strong subjective degree of belief against it. In this exercise, acute MI is inferred conclusively and accurately from the test result, acute ST elevation EKG changes alone by interpreting it as strong evidence. This diagnosis is made, we suggest, due to its high reliablity as it is validated by our experience of inferring acute MI from acute ST elevation EKG changes accurately in 8 to 9 out of 10 (around 86 percent) patients with varying prior probabilities (7).

We shall now consider the consequences of employing the Bayesian method for diagnosis in another patient often seen in practice, who is a 65 year old man with multiple cardiac risk factors presenting with highly characteristic chest pain in whom acute MI is suspected and an EKG performed to evaluate it, which reveals non-specific T wave EKG changes with LR of 1. In the Bayesian method, the prior probability of acute MI, let us assume it is 86 percent, is combined with the LR of 1 to generate a posterior probability of 86 percent (Appendix 2).

The very high prior probability of 86 percent would be interpreted as very strong prior subjective belief for acute MI in this patient which again raises the issue of why we do not infer acute MI from it alone without proceeding to do an EKG. The applied statistician Ehrenberg (6) again notes about the Bayesian method, that if the prior is strong, why collect new data? The other issue, as in the other patient is about conclusive Bayesian inference of acute MI from the very high posterior probability of 86 percent interpreted as strong total belief in this patient with non-specific T wave EKG changes. This Bayesian inference will not be made in practice, we believe, because it is not supported by our experience of finding the test result, non-specific T wave EKG changes with LR of 1, to be worthless in diagnosing acute MI in any patient.

We note from the above two patients that the consequences of employing the Bayesian method in practice would be diagnostic errors due to making diagnoses which are unreliable as they are not supported by our experience. We believe, the Bayesian method is not suitable in principle for diagnosing any disease with a high degree of accuracy in different patients with varying prior probabilities. This is the reason, we suggest, it is not employed for diagnosis in practice as achievement of high accuracy in diagnosis of a disease in any patient regardless of prior probability is the primary goal of all practicing physicians.

The method that is actually employed for diagnosis in practice consists, we suggest, of formulating a suspected disease as a hypothesis without any prior probability attached to it so that it does not have any prior degree of belief or evidence for or against it. This hypothesis is evaluated by performing a test and verified to be correct, if a highly informative test result with LR greater than 10 is observed (8), with a high degree of accuracy (85 percent or greater) in any patient regardless of prior probability. For example, acute MI would be suspected from the presentation in the 40 year old woman as well as in the 65 year old man mentioned above and formulated as a hypothesis without any prior probability attached to it in both patients in practice. This hypothesis would be evaluated by performing an EKG which would be verified to be correct with a diagnostic accuracy of about 86 percent in both patients if acute ST elevation EKG changes, LR 13 are observed in them. We shall characterize and describe this method in detail in another paper which we shall post shortly on Discussion Board.

The fact that the prescribed Bayesian method is not employed for diagnosis in practice is not surprising in one sense as it was not prescribed due to its diagnostic accuracy. Instead, it was prescribed, we believe, due to its coherence (9) which is defined in terms of not losing a bet placed on a Bayesian inference from a posterior probability with odds based on the posterior probability. Thus Bayesian inference is considered coherent as a Dutch book, which is a series of bets which ensures betting loss, cannot be created against the inferring agent with this method. But our goal as practicing physicians is not to achieve coherence in diagnosis but to achieve high diagnostic accuracy, and coherence of the Bayesian method does not translate into high diagnostic accuracy as we note in the two patients discussed earlier. Thus the Bayesian inference of acute MI being indeterminate from a posterior probability of 50 percent in the 40 year old woman with acute ST elevation EKG changes can be considered coherent by looking at it as a bet placed with odds of 1 to 1 on this inference. But this coherence does not help in anyway in inferring acute MI accurately in this patient. Similarly, in the 65 year old man with non-specific T wave EKG changes, the Bayesian inference of acute MI being present with a high degree of certainty from the posterior probability of 86 percent can be considered coherent by looking at it as a bet made with odds of 86 to 14. But this coherence does not help again in anyway in diagnosing acute MI accurately in this patient. Thus there is no correlation between coherence and inferential (diagnostic) accuracy. The eminent Bayesian statistician, Dennis Lindley, has said as much by noting, “The Bayesian theory is about coherence, not about right or wrong” (10).

If we look at the Bayesian approach to diagnosis from the perspective of diagnostic accuracy, its shortcomings even in theory are quite obvious. For example, the Bayesian notion of interpreting a prior probability as a subjective degree of belief for or against a disease seems counterproductive to achieving high diagnostic accuracy when a disease is known to occur in patients with high as well as with low prior probabilities. In fact, we believe, it encourages diagnostic errors, which have been reported in several studies (11,12), by failing to suspect or test a disease with an atypical presentation by interpreting its low prior probability as subjective degree of belief against it. Then, there is no distinction made in the Bayesian approach, as we discussed above, between a highly informative test result such as acute ST elevation EKG changes with LR of 13 and a worthless test such as non-specific T wave changes with LR of 1 in diagnosis of a disease such as acute MI, which is likely to lead to diagnostic errors. In addition, the estimation of a prior probability of a disease from its prevalence has been found to be highly inaccurate (13) which adds another layer of difficulty in employing the Bayesian method for diagnosis in practice. In fact we cannot think of any feature of the Bayesian approach which facilitates accurate diagnosis of a disease in patients with varying prior probabilities.

Several strategies that are recognized as improving diagnostic accuracy and are routinely employed in practice are inconsistent with the Bayesian approach. Thus the creation of a comprehensive differential diagnosis, which includes diseases with low prior probabilities is known to be extremely valuable in reaching a correct diagnosis (14). In the Bayesian approach however, a disease with a low prior probability may not be included in a differential diagnosis due to subjective prior degree of belief against it, which may lead to a diagnostic error. Furthermore, asking the question “What else could it be” in a difficult diagnostic situation is well recognized to be an important strategy in a difficult diagnostic situation (15) which makes us think of diseases with very low prior probabilities as plausible causes. This strategy appears to be inconsistent with the Bayesian approach in which such diseases may not be considered due to very strong prior subjective degrees of belief against them.

We have not found any published case report or series in which the Bayesian method has been employed for diagnosis in real patients. In our own personal experience and observation of practicing physicians around us, we have not found the Bayesian method to be employed for diagnosis. We note, for example, that the diagnosis of covid-19 disease is not made in practice in a Bayesian manner. This disease is diagnosed conclusively with a very high degree of accuracy in any patient who has a positive covid-19 PCR test with LR of 14 regardless of its presentation or prior probability (16) clearly indicating the Bayesian method is not being employed. We agree with the eminent clinical investigator, Alvan Feinstein (17), who noted, “I know of no clinical setting or institution in which the Bayesian diagnostic methods are being regularly used for practical diagnostic purposes in a routine or specialized manner".

In our view, the single most important feature of the Bayesian method which causes problems in achieving diagnostic accuracy is the interpretation of a prior probability as prior subjective degree of belief for or against a disease in a patient. It is this feature which is likely to lead to a disease with an atypical presentation (low prior probability) not being suspected or tested, thus causing a diagnostic error. And it is the combination of a prior probability with LR of a test result to generate a posterior probability which masks the highly informative content of a test result such as acute ST elevation EKG changes with LR of 13 and inflates the diagnostic capability of a worthless test result such as non-specific T wave EKG changes with LR of 1 as we saw in the above two patients, which is likely to lead to diagnostic errors.

In the method which is actually employed for diagnosis in practice, the biggest difference from the Bayesian method is in not interpreting a prior probability as a prior degree of belief. It is due to this difference, we believe, that experienced physicians diagnose diseases with atypical presentations (low prior probabilities) accurately on a routine basis in published diagnostic exercises in real patients (2,3).In addition, a prior probability is not combined with a LR to generate a posterior probability in practice so that a test result such as acute ST elevation EKG changes with LR of 13 remains highly informative and is employed for inference in every patient for inference of acute MI, regardless of its prior probability as we saw in the 40 year old woman discussed above.

Thus, while the features of interpreting a prior probability as a prior degree of belief and combining it with a LR to generate a posterior probability may be required in Bayesian theory to achieve coherence in inference, they are not employed in diagnosis in practice as they lead to errors in diagnosis of a disease in patients with varying prior probabilities. Therefore, an entirely different method, in which these features do not play any role, is employed for diagnosis in practice. We shall characterize and describe this method in detail in another paper which shall be posted on Discussion Board shortly.

Appendix 1

Prior probability of 7 percent = Prior odds of 7/93

In odds form of Bayes' theorem,

Prior odds x Likelihood ratio = Posterior odds

Therefore,

7/93 x 13 = 1/1 = Posterior probability of 50 percent.

Appendix 2

Prior probability of 86 percent = Prior odds of 86/14

In odds form of Bayes' theorem,

Prior odds x Likelihood ratio = Posterior odds

Therefore, 86/14 x 1 = 86/14 = Posterior probability of 86 percent.

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