The Bayesian method, in which a disease is inferred from a posterior probability generated by combining a prior probability and a likelihood ratio was prescribed for diagnosis in the early 1960s on grounds of the rationality of this method (1). This rationality was defined in terms of not losing a bet placed on a probabilistic inference (diagnosis). In this paper, we shall assess the Bayesian method from the perspective of inferential (diagnostic) accuracy which has not been taken into account in its prescription for diagnosis.

We have pointed out, Bayesian inference is not employed during diagnosis in practice as seen in diagnostic exercises in real patients such as clinicopathologic conferences (CPCs) and clinical problem solving exercises which are published regularly in the New England Journal of Medicine (2,3). In these exercises, diagnosis is performed by highly experienced, academic physicians who would employ Bayesian inference, we believe, if it was helpful in reaching an accurate diagnosis in a patient. It is not employed, we suggest, because it is likely to lead to diagnostic errors in some patients as we discuss below.

The key feature of Bayesian inference which is likely to lead to diagnostic errors is the notion of a presentation as a source of prior evidence represented by prior probability of a disease (4).

From a clinical standpoint, the value of this notion in diagnosis is not clear, because it is well known from experience that any given disease occurs in different patients with varying presentations and therefore with varying prior probabilities which range from being low to high. For example, acute myocardial infarction (MI)occurs in a healthy 40 year old woman without any cardiac risk factor presenting with highly uncharacteristic chest pain in whom the prior probability of acute MI is very low at 7 percent (5).

In the Bayesian approach, this very low prior probability represents very strong prior evidence against acute MI in this patient which may prompt us not to suspect or test acute MI in this patient which would be a serious diagnostic error as this patient did have acute MI. It appears to us that the Bayesian approach may encourage diagnostic errors due to failure to suspect a disease with an atypical presentation which have been reported in several studies (6,7).

Acute MI occurs as well in a 65 year old man with multiple cardiac risk factors presenting with highly characteristic chest pain in whom the prior probability is very high say 85 percent. In the Bayesian method we would be justified in inferring acute MI from this very high prior probability as strong prior evidence which is however never done in practice without testing.

In the Bayesian method, a prior probability is combined with likelihood ratio (LR) of a test result to generate a posterior probability which represents total evidence from which a disease is inferred (4). However the level of high posterior probability from which a disease is definitively inferred is not well defined. Let us assume it is 85 percent or higher.

We note that in the 40 year old woman in whom the prior probability of acute MI is 7 percent, we would require a test result with LR of 74 to generate a posterior probability of 85 percent (Appendix 1).

And in the 65 year old man in whom the prior probability of acute MI is 85 percent, we would require a test result with LR of only 1 (such as non-specific EKG changes) to generate a posterior probability of 85 percent (Appendix 2).

In other patients in whom we suspect acute MI and in whom its prior probability varies from 7 to 85 percent, we would require test results with LRs from 74 to 1 to generate a posterior probability of 85 percent.

We note that we would require a test result with a different LR in different patients depending on the prior probability to infer a disease from posterior probability of 85 percent in the Bayesian method. This would cause several problems in practice. First of all, it is not always possible to estimate the prior probability of a disease accurately in every patient as its prevalence from which it is usually estimated may not be known. We would then need to figure out the test which would yield a result with the appropriate LR to generate the posterior probability of 85 percent which may be tricky in some patients. And in patients with extremely low or high prior probability of acute MI, we would require a test result with very high LR or one with a value of 1 (that is a worthless test result).

And worst of all, we would not have any idea about the inferential accuracy of inference of acute MI from a posterior probability of 85 percent as the inference would be done in different patients with different test results.

Due to all these problems, Bayesian inference is not employed, as we have noted, during diagnosis in practice despite having been prescribed for over 50 years.

We cannot think of a single reason from the point of view of inferential (diagnostic) accuracy that we should be using Bayesian method for inference during diagnosis in practice.

We shall now describe the method which is employed for inference during diagnosis in practice to achieve our goal of inferential (diagnostic) accuracy in every patient regardless of presentation (prior probability of a disease).

The most important feature of the method in practice is that a presentation is not a source of prior evidence in it. Instead, a presentation is merely a clue which makes us suspect a disease regardless of whether the presentation is typical (high prior probability) or atypical (high prior probability).

The suspected disease is then formulated as a diagnostic hypothesis without any prior probability attached to it so that it does not have any prior evidence for or against it as we see clearly in all published CPCs and clinical problem solving exercises (2,3).

Thus acute MI would be suspected in practice from the presentation in the 40 year old woman as well as in the 65 year old man and formulated as a diagnostic hypothesis without any prior evidence for or against it in both patients despite the very different prior probabilities in them.

Acute MI as a diagnostic hypothesis is evaluated in both patients by performing a test, an EKG. And if acute ST elevation EKG changes with LR of 13 (8) are observed in both patients, this test result would be interpreted as strong evidence from which acute MI would be inferred in both patients. This inference is based on the observed high frequency of 85 percent of accurate inference of acute MI from acute ST elevation EKG changes in patients with varying prior probabilities (9).

This high frequency validates, so to speak, the inference of acute MI from acute ST elevation EKG changes in a given patient regardless of prior probability.

The method of inference in practice described above is the frequentist method of (statistical inference) which we have discussed in detail elsewhere (10).

We note any disease which has a test capable of generating a result with LR greater than 10 (11) is inferred in practice in a frequentist manner. For example, pulmonary embolism is inferred from positive chest CT angiogram, LR 20 (12)and deep vein thrombosis is inferred from positive venous ultrasound study, LR 16 (13) in any patient regardless of prior probability with high inferential accuracy.

The availability of such a test often has a dramatic effect on increasing diagnostic accuracy of a disease which is seen most clearly in the case of pulmonary embolism. It was only with the availability of perfusion lung scan and chest CT angiogram which can generate results with LR greater than 10, that accurate diagnosis of pulmonary embolism in patients with varying presentations (prior probabilities) became possible.

We note that the Bayesian step of combining a prior probability with a likelihood ratio artificially dilutes the inferential capability of a highly informative test result in a patient with low prior probability of disease. For example, acute ST elevation EKG changes with LR 13, is known to be a highly informative test result. In the 40 year old woman mentioned above in whom the prior probability of acute MI is 7 percent, the LR of 13 of this test result is combined with the prior probability of 7 percent in the Bayesian method to generate a posterior probability of 50 percent (5) (Appendix 3) from which acute MI would be inferred to be indeterminate in this patient! The discussing physician in the clinical problem solving exercise in which this real patient is discussed, rejects this Bayesian inference and instead infers acute MI definitively from acute ST elevation EKG changes alone (5).

In conclusion, it is considering a presentation as a source of evidence in the form of a prior probability representing prior evidence in the Bayesian method which leads to many undesirable consequences that make it unsuitable for inference

during diagnosis causing it not to be employed during diagnosis in practice. These undesirable consequences are as follows:

(a) A disease with an atypical presentation may not be suspected due to its low prior probability being interpreted as prior evidence against it.
(b) The distinction between a highly informative test result with LR greater than 10 and a worthless test result with LR close to 1 is lost as the former combined with a low prior probability generates a low posterior probability and the latter combined with a high prior probability generates a high posterior probability. In the Bayesian method, it is the posterior probability as total evidence from which a disease is inferred.
(c) Different test results with different LRs are employed to infer a given disease in different patients with varying prior probabilities.
(d) The accuracy of the Bayesian method for inferring a given disease is unknown due to different test results being employed in different patients to infer it.

All these undesirable consequences are avoided in practice by not considering a presentation as a source of evidence and thus not employing the Bayesian method for inference. In practice, the frequentist method is employed which has the following desirable features which ensure high diagnostic accuracy in all patients regardless of presentation (prior probability):

(a) A suspected disease is formulated as a diagnostic hypothesis without any prior probability attached to it so that it does not have any prior evidence for or against it in any patient regardless of presentation (prior probability). This is clearly seen in all published CPCs and clinical problem solving exercises in which all diseases in a differential diagnosis in a patient are diagnostic hypotheses regardless of their prior probabilities (2,3).
(b) A test result with LR greater than 10 is clearly recognized as being highly informative which is employed for inference in all patients regardless of prior probabilities if a disease has a test capable of generating such a result.
(c) The accuracy of a test result in inferring a disease is known, as the same test result is employed to infer it in all patients regardless of prior

probability. For example, the inferential (diagnostic) accuracy of acute ST elevation EKG changes, LR 13 in inferring acute MI accurately in patients with varying prior probabilities is 85 percent (9).,

(d) This method of inference is extremely simple as a suspected disease is inferred as soon as a test result with LR greater than 10 is observed regardless of its prior probability.

We believe it is time now to re-evaluate and perhaps discontinue the prescription of the Bayesian method for diagnosis in practice as it was prescribed more than 50 years back for its rationality in terms of not losing a bet which is not our goal in diagnosis. This method is not employed during diagnosis in practice as it fails to achieve our goal in diagnosis of inferring a disease accurately in every patient regardless of presentation (prior probability). It is time, we believe, that we recognize the method that is employed during diagnosis in practice, which is the frequentist method. This is the method which should be prescribed which would then align theory and practice of diagnosis.

Appendix 1

Prior probability of 7 percent = Prior odds of 1/13

Posterior probability of 85 percent = Posterior odds of 85/15.

In odds form of Bayes' theorem,

Likelihood ratio = Posterior odds/Prior odds = 85/15 x 13/1 = 74

Appendix 2

Prior probability of 85 percent = Prior odds of 85/15

In odds form of Bayes' theorem,

Likelihood ratio = Posterior odds/Prior odds = 85/15 divided by 85/15 = 1

Appendix 3

Prior probability of 7 percent = Prior odds of 7/93 = 1/13

In odds form of Bayes' theorem

Prior odds x Likelihood ratio = Posterior odds

Thus, 1/13 x 13 = 1 = Posterior probability of 50 percent

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