In this paper we shall investigate what the correct method of diagnosis is. This investigation is necessary because of the wide divergence between theory and practice regarding the method of diagnosis. In theory, the Bayesian method, in which probability of a disease is considered evidence from which it is diagnosed in a given patient, has been prescribed for diagnosis on grounds of the rationality of this method for any uncertain inference (1). In practice, however, the Bayesian method is not employed for diagnosis in practice, as we see in clinicopathologic conferences (CPCs) and clinical problem solving exercises in which probability of a disease is not considered evidence for it (2,3).

We find the Bayesian method is employed successfully in practice in the life insurance business in which age of death of a person is inferred from the probability of this event (3). This method ensures that this inference is correct in the long run in a series of similar persons though errors may occur in some individual persons. This outcome is consistent with the goal in this business of long run accuracy and gain with tolerance for error and loss in some individual persons.

We suggest it is not so much the rationality of the Bayesian method, but the fact that it helps achieve the goal of long run accuracy that it is employed for inference in the life insurance business.

Similarly we believe the Bayesian method would be employed for diagnosis in practice if it helped achieve the goal in diagnosis of determining a disease correctly in a given, individual patient with symptoms.

Let us now examine why the Bayesian method is not employed for diagnosis in practice.

In this method, the prior probability of a suspected disease is estimated from its prevalence and it is considered to be prior evidence for it in a given patient (1). We find this notion to be problematic from a clinical standpoint because a prior probability being a frequency in a population (1) represents an average value as we see from the following example:
Let us suppose the prior probability of a disease in a patient is 0.2 or 20 percent. It indicates that that the disease is present in 20 out of 100 patients in a population so that the average value of the disease in one patient is 0.2.

The prior probability of 0.2 as an average value does not inform us anything about presence or absence of the disease in the given patient and thus fails to represent prior evidence for it in this patient. It merely tells us that this patient belongs to a population in which 20 out of 100 patients have the disease.

If a prior probability is considered prior evidence as proposed in the Bayesian method, it would lead us not to suspect a disease with an atypical presentation by interpreting its low prior probability as prior evidence against it in a given patient.

The Bayesian method thus appears to encourage failure to suspect a disease with an atypical presentation which has been reported to be an important cause of diagnostic errors in several studies (4,5).

It is for this reason, we suggest, that a suspected disease is not assigned any prior evidence regardless of its prior probability by experienced physicians in CPCs and clinical problem solving exercises (2,3). Every suspected disease is formulated as a diagnostic hypothesis in them which means it is an assumption which may or may not prove to be correct on evaluation.

The formulation of every suspected disease as a diagnostic hypothesis is a major factor, as we have pointed out, in correct diagnosis of a disease with atypical presentation (low prior probability) with relative ease in CPCs (2).

In the Bayesian method, a disease is diagnosed in a given patient from a posterior probability generated by combining a prior probability with likelihood ratio for a test result by Bayes theorem, which is considered total evidence.

The diagnosis of a disease in this manner is likely to lead to diagnostic errors as illustrated by the two following patients:

The first patient, a real patient discussed in a clinical problem solving exercise (6), is a healthy 40 year old woman without any cardiac risk factor who presents
with highly uncharacteristic chest pain and is found to have acute Q wave and ST elevation EKG changes (acute EKG changes).

The prior probability of acute myocardial infarction (MI) in this patient is estimated to be 7 percent from its prevalence. It is combined with the likelihood ratio (LR) of 13 for acute EKG changes (7) to generate a posterior probability of 50 percent (Appendix 1).

In the Bayesian method, acute MI would be incorrectly diagnosed to be indeterminate in this patient from this posterior probability.

The discussing physician in this exercise, however correctly diagnoses acute MI definitively in this patient from the high LR of 13 for acute EKG changes alone.

The second patient, a hypothetical patient often seen in practice, is a 65 year old man with multiple cardiac risk factors who presents with highly characteristic chest pain and is found to have non-specific T wave EKG changes.

Let us suppose the prior probability of acute MI is estimated to be 85 percent in this patient from its prevalence which is combined with the LR of 1 for non-specific T wave EKG changes to generate a posterior probability of 85 percent (Appendix 2).

In the Bayesian method, acute MI would be diagnosed with a high degree of certainty in this patient from the posterior probability of 85 percent. We doubt however if this diagnosis will be made in practice in this patient with non-specific T wave EKG changes. In all likelihood, further tests would be performed to evaluate presence or absence of acute MI in this patient.

We suggest acute MI is not diagnosed from the posterior probability in these two patients, because it too, like a prior probability indicates an average value, which tells us nothing about presence or absence of acute MI in the given patient.
The likelihood ratio for acute EKG changes, on the other hand, represents a change in odds (probability) of acute MI in a given patient as we see from the odds form of Bayes’ theorem below:

\[
\text{Likelihood ratio} = \frac{\text{Posterior odds}}{\text{Prior odds}} \quad (i)
\]

As this change occurs in a given patient of interest, a likelihood ratio represents evidence for acute MI in this particular patient.

Thus the likelihood ratio of 13 for acute EKG changes, which indicates a thirteenfold increase in odds of acute MI in the 40 year old woman is considered strong evidence from which acute MI is diagnosed definitively despite a posterior probability of only 50 percent in this patient.

In the 65 year old man, on the hand, the likelihood ratio of 1 for non-specific T wave EKG changes indicates no change in odds of acute MI thus providing no evidence for it so that it is not diagnosed with any certainty in this patient despite a posterior probability of 85 percent.

We note from Equation (i) that the change in odds represented by a likelihood ratio is independent of prior probability indicating that acute EKG changes provide the same strong evidence for acute MI in every patient regardless of prior probability. This is the reason, we suggest, that it is customary in practice to diagnose acute MI definitively in any patient with acute EKG changes regardless of prior probability (8).

In practice, a test result with likelihood ratio greater than 10 is considered strong evidence (9) from which a disease is diagnosed definitively in any patient regardless of prior probability. Thus in addition to diagnosis of acute MI from acute EKG changes, pulmonary embolism is diagnosed from positive chest CT angiogram, LR 20 (10) and deep vein thrombosis from positive venous ultrasound, LR 16 (11) in this manner.

In all CPCs and clinical problem solving exercises, a suspected disease as a diagnostic hypothesis is confirmed to be correct from likelihood ratio of data or test result provided.
In addition to the above discussion, the fact that the Bayesian method is not employed for diagnosis in any one of the scores of published CPCs and clinical problem solving exercises seems to indicate, we believe, that it is not the correct method of diagnosis.

The correct method of diagnosis as seen in CPCs and clinical problem solving exercises consists of formulating a suspected disease as a diagnostic hypothesis and confirming it by a likelihood ratio as evidence. This method enables us to diagnose a disease accurately in a given, individual patient. This method is the same as the scientific method as we have pointed out elsewhere (12).

Appendix 1

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

Therefore,

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

Appendix 2

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

In odds form of Bayes’ theorem,

Prior odds x Likelihood ratio = Posterior odds

Therefore,

85/15 x 1 = 85/15 = Posterior probability of 85 percent
References
